the birds did not resort thither in search of food for the young, but obtained it in the vicinity of the nesting site.

It was extremely difficult to photograph these birds owing to the fact that their movements were so rapid; they would descend to the entrance of the nest like a streak of pale blue lightning, and in a flash would enter.

Thus one was obliged to work the shutter at a great speed, and even then it often happened that, instead of finding the whole bird visible on the negative, perhaps only the tail would be seen projecting from the entrance.

The brilliance of the blue on the wings, with the sun shining on it, may be judged from the photographs—the blue is rendered an absolute white.

The young were a fortnight old when they left the nest and did not return to it.

THE ORGANIC CELL

Part III.—Its Methods of Division and Status in the Process of Heredity

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Schleiden, that famous pioneer of the cell-theory, assumed that cells arose by a process of crystallisation from an unorganised substance which he termed 'cytoblastema.' The later work of Remak, Kölliker, and others soon refuted this theory, and shortly afterwards, the very important teaching of Virchow that 'all cells come from pre-existing cells' came to be accepted, and since then this doctrine has become one of the central and fundamental principles of modern biology. Every cell is the result of the division of a pre-existing cell; this process having gone on far back through the ages that have been, to the very dawn of all life. Life results from pre-existing life; the so-called process of 'spontaneous generation' certainly does not exist at the present time.

Remak, as a result of his work on cell-division in the years

1855 to 1858, came to the conclusion that cell-division proceeds from the centre to the periphery. Commencing in the nucleolus which divides, the process is continued in the nucleus, and afterwards is completed by the division of the cell-body and envelope. For nearly twenty years this was the accepted teaching regarding cell-division. In the year 1873 a set of most important discoveries were made, which showed clearly that cell-division was in very many cases a most complicated process, involving an extremely intricate change in the nucleus to which Schleicher gave the name of *Karyokinesis*. It must be remembered, however, that this complicated process is not absolutely universal, and that there is another simpler, though much rarer, method of division, corresponding to that described above by Remak, and which van Beneden characterised as fragmentation.

To be brief, it may be stated that there are two recognised methods of cell-division for which Flemming proposed the terms direct and indirect division, terms still in use. Later Flemming proposed to substitute for these :—

Amitosis, representing the direct method, and *Mitosis*, the indirect or Karyokinetic method.

It has been demonstrated that the method of direct division is a very rare process, and occurs during the life history of cells which are undergoing degenerative changes, and are on the downward path to disintegration. It appears to be a sign of degradation in specialised cells which are incapable of long-continued division. It is very characteristic of the cells forming temporary embryonic envelopes &c. In this form of cell-division the nucleus becomes divided into two portions, followed by a similar division of the cytoplasm.

Indirect Division or Mitosis

In this description I shall take a type of *Mitosis* in which a persistent centrosome is present, as has been demonstrated in the division of the testis-cells. In a series of articles of this kind it would be superfluous, and possibly a little exhausting to the reader, to point out the variations in detail occurring in different animals and plants. There are many minute differences which, however, do not affect the final result; this in all cases consists of the equal longitudinal division of the chromosomes of the parent nucleus between the two daughter nuclei.

The process of *Mitosis* includes three parallel sets of changes, affecting the nucleus, centrosome, and cytoplasm respectively. It is usual for descriptive purposes to divide it into a series of phases, which, it must be remembered, are not separated from one another by any sharp lines, but graduate gently one into the other.

Phases of Cell Division by *Mitosis* or *Karyokinesis* :—

I. *Prophases.*	1. Resting nucleus. 2. Skein stage of chromatin. 3. Segmented skein.
II. *Metaphase.*	4. Equatorial plate, and splitting of chromosomes.
III. *Anaphases.*	5. Movement of chromosomes to poles, and formation of 6. Segmented daughter skeins.
IV. *Telophases.*	7. Reconstruction of nucleus. 8. Division of cytoplasm.

I. *Prophases.* (*a*) *The Nucleus.*—As a preparatory measure to division, the nuclear substance becomes altered both physically and chemically. There is a resolution of the chromatin substance into a convoluted thread, known as the skein or spireme. On its first appearance, this skein is closely convoluted, the 'close spireme': shortly, however, there is a distinct shortening and thickening to form the 'open spireme.' The substance of the spireme now stains intensely, and for this reason can very easily be distinguished from the reticulum. The thread now segments transversely, forming a series of rod-like bodies called chromosomes. (See diagram, p. 102.) The chromosomes, though very often rod-like in shape, may assume other forms—they may be spherical, or even in the form of rings. At this stage of cell-division the chromatin possesses its maximum staining capacity. The membrane surrounding the nucleus fades away, the nuclear ground substance becomes continuous with the cytoplasm of the cell-body, and the chromosomes lie naked in this substance.

It is a remarkable fact that the number of chromosomes for each species of animal or plant is constant. For example, in the common mouse there are twenty-four ; in man, the guinea-pig, and onion the number is sixteen ; in the grasshopper twelve, and so on. These numbers recur regularly in the division of all of the cells. It is interesting to know that in all forms arising by sexual reproduction the number is even. As will be seen later on, the even number results from the fact that one half of the chromosomes is derived from each of the parents.

As regards the fate of the nucleoli, it may be stated that the net-knots, which are composed of chromatin, assist in the formation of the chromosomes ; while the plasmosomes, or true nucleoli, which are devoid of chromatin, disappear.

(*b*) *The Amphiaster.*—In the meantime a spindle-shaped body makes its appearance at the site of the original nucleus. At either pole of this spindle a star forms, the radiating fibres of which are called astral rays—these rays passing into the substance of the cell-body. In the centre of each star is found a centrosome, and usually surrounding the centrosome a clear substance called the centrosphere. According to van Beneden and Boveri the centrosome is the 'dynamic centre' which initiates these various changes. The chromosomes now arrange themselves in the region of the equator of the spindle, forming what is known as the equatorial plate (see diagram, p. 102). According to the most recent researches, it would appear that the astral rays have the power of forcing their way into the nucleus, attaching themselves to the chromosomes, and then, by a process of contraction, pulling them to the equator of the spindle. The complete form thus produced is called the Mitotic figure, and, as will easily be seen by reference to the diagram (F), consists of a Chromatic figure, formed of the chromosomes, and an Achromatic figure, which includes the rest, namely asters and spindle.

II. *Metaphase.*—The changes so far accomplished have been of a preparatory nature, and in the metaphase which follows, the most important act in the whole process of cell-division occurs. This consists in the longitudinal splitting of each chromosome into two exactly equal parts, and the

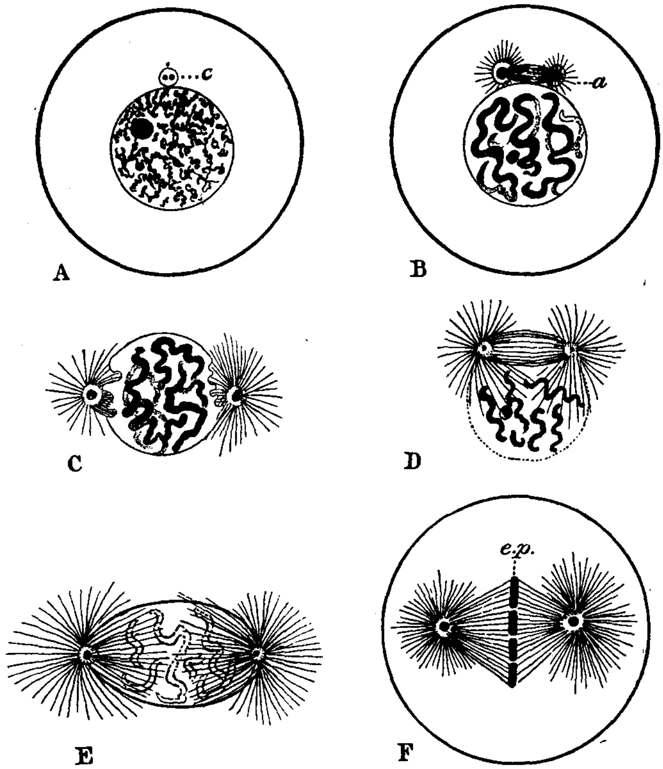


DIAGRAM SHOWING THE PROPHASES OF MITOSIS.

A. Resting cell with reticular nucleus and true nucleolus; at C the attraction sphere containing 2 centrosomes. B. Early prophase, the chromatin forming a continuous spireme, nucleolus still present, above the amphiaster *a*. C, D. Two different types of later prophases. C. Disappearance of the primary spindle, divergence of the centrosomes to opposite poles of the nucleus (examples, some plant-cells, cleavage stages of many eggs). D. Persistence of the primary spindle (to form in some cases the 'central spindle') fading of the nuclear membrane, ingrowth of the astral rays, segmentation of the spireme thread to form the chromosomes (examples, epidermal cells of Salamander, formation of the polar bodies). E. Later prophase of type C; fading of the nuclear membrane at the poles, formation of a new spindle inside the nucleus; precocious splitting of the chromosomes (the latter not characteristic of this type alone). F. The mitotic figure established; *e.p.* the equatorial plate of chromosomes.

moving apart of the halves. This splitting of the chromosomes is of the greatest theoretical significance, for by it the original chromatin is equally distributed between the two daughter nuclei, each receiving a half of each original chromosome. The importance of the process cannot for a moment be doubted when one considers the elaborate mechanism, and the vast

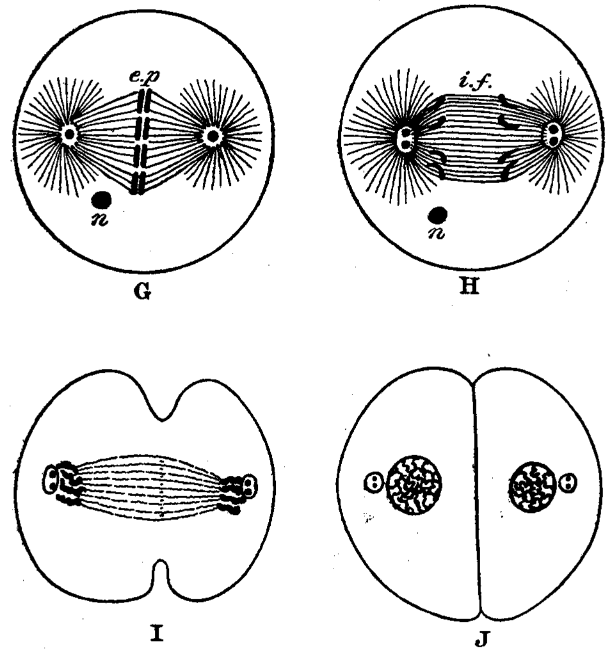


DIAGRAM OF THE LATER PHASES OF MITOSIS.

G. Metaphase: splitting of the chromosomes (*e.p.*), *n.* the cast-off nucleolus. H. Anaphase. The daughter-chromosomes diverging; between them the interzonal fibres (*i.f.*). Centrosomes already doubled in anticipation of the ensuing division. I. Late Anaphase or Telephase, showing division of the cell-body, mid-body at the equator of the spindle, and commencing reconstruction of the daughter-nuclei. J. Division completed.

amount of energy expended in this careful longitudinal division of each chromosome. If the mere quantitative division of the chromatin was required, a simple mass division would have sufficed, but the fact that such an exceedingly complicated mechanism should be brought into play shows clearly that the distribution of the definite organisation of the chromatin to the daughter cells is of the greatest possible importance.

Put briefly, it may be stated that in some cases the chromosomes do not split longitudinally until they have arranged themselves in the equatorial plane of the spindle—in other cases the splitting occurs in the spireme stage, or even earlier, but such exceptions do not in any way affect the central fact that the 'chromatin network is converted into a thread, which, whether continuous or discontinuous, splits throughout its entire length into two exactly equivalent halves.' This essentially important phenomenon was discovered by Flemming in 1880. It is very noteworthy, that the nuclear division always shows this mathematical equality, whether the division of the cell-body is equal or otherwise.

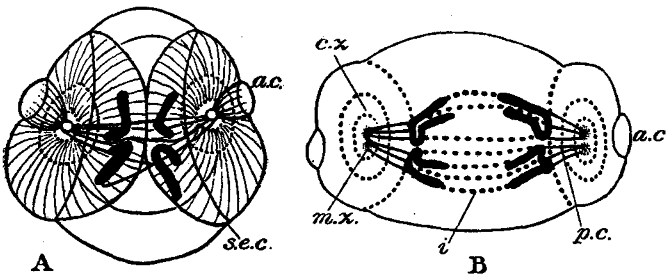
III. *Anaphases.*—The daughter chromosomes, which result from the longitudinal splitting of the original ones, diverge to opposite poles of the spindle. As they separate, they are seen to be connected by fibres called interzonal fibres. These are believed by some to have a special origin and function, and to be quite distinct from the ones forming the spindle. They almost invariably have a row of deeply staining bodies in the plane of the equator called the mid-body. It is interesting to note that, in the *Mitosis* of plant-cells, the mid-body is very marked.

IV. *Telophases.*—The entire cell now divides along the plane of the equator of the spindle into two daughter-cells, in each of which a daughter nucleus is formed from the chromosomes it contains.

The Mechanism of Mitosis

Van Beneden's hypothesis of fibrillar contractility is, up to the present, the most satisfactory explanation of the phenomena of *Mitosis*. To quote his own words: 'In our opinion all the internal movements that accompany cell-division have their immediate cause in the contractility of the protoplasmic fibrillæ, and their arrangement in a kind of radial muscular system, composed of antagonising groups. In this system the central corpuscle (centrosome) plays the part of an organ of insertion. It is the first of all the various organs of the cells to divide, and its division leads to the grouping of the contractile elements in two systems, each having its own centre. The presence of these two systems brings about cell-division, and actively determines the paths of the secondary chromatic asters in opposite directions. An important part of the phenomena of *Karyokinesis* has its efficient cause, not in the nucleus, but in the protoplasmic body of the cell.' (See diagram below after van Beneden and Iulin, also the diagram of Heidenhain's model of *Mitosis*.)

Th. Boveri shortly afterwards accepted van Beneden's views, and by his own observations did much to support the theory

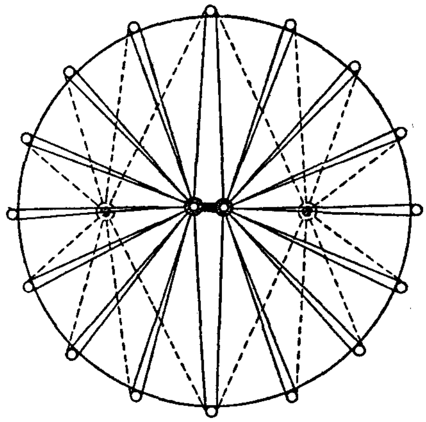


FIGURES OF DIVIDING EGGS OF ASCARIS ILLUSTRATING VAN BENEDEN'S THEORY OF MITOSIS. (Van Beneden & Iulin.)

A. Early Anaphase: each chromosome has divided into two. B. Later anaphase showing divergence of daughter chromosomes. *a.c.* Antipodal cone of astral rays. *c.z.* Cortical zone of attraction sphere. *i.* Interzonal fibres. *m.z.* Medullary zone of attraction sphere. *p.c.* Principal cone forming one half of the contractile spindle. *s.e.c.* Sub-Equatorial circle to which the astral rays are attached.

of contractility. He demonstrated that, when a chromosome splits, each half is connected with rays from the aster on its own side, that these rays shorten and thicken as the half chromosomes are drawn apart. The rays behave, in fact, precisely in a similar manner to muscular fibres, and from a careful study of his work it seems impossible to doubt the theory of the contractility of the fibrillæ.

This hypothesis of contraction is very clearly brought out in models designed by Heidenhain. The model is easily made by marking a circle on a flat surface, and attaching at regular intervals along the margin of the circle a set of rubber bands, which represent the astral rays. The central ends of the rubber bands are attached to two small rings, which simulate the centrosomes, and these two small rings are fastened together. Should the fastening of the centrosomes be severed, they are at once separated forcibly, until they reach a new position of equilibrium, when it will be seen that the rays are arranged in two asters exactly as occurs in the cell. (See diagram.) To whatever cause *Mitosis* is due, the result is



HEIDENHAIN'S MODEL OF MITOSIS.

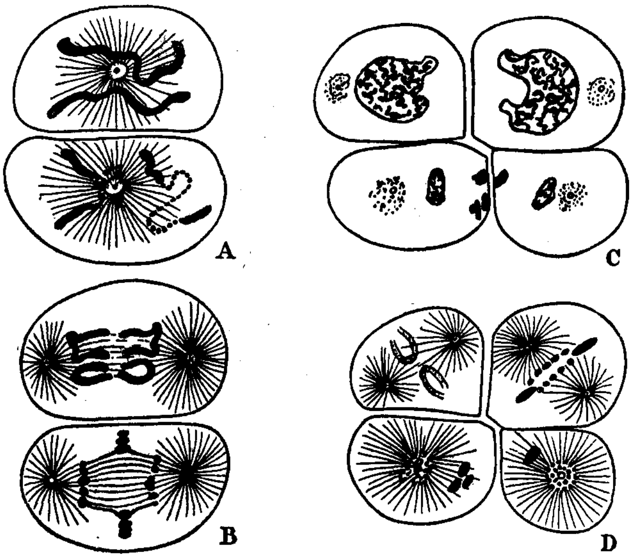
Dotted lines show position of the rays on severing the connection between the small rings (Centrosomes).

that there is an equal division of the chromatin of the mother-cell, and an equal distribution of the same to the nuclei of the daughter cells.

ORIGIN OF THE GERM-CELLS

The germ-cells arise from what are called primordial germ-cells, which can easily be differentiated from the 'somatic-' or body-cells at a very early stage in development. It is interesting to note that at this early stage the cells are exactly alike for the two sexes. With very few exceptions it would appear that the primordial germ-cells are indifferent as regards sex, and what determines their final development into spermatozoon or ovum merely depends on external causes. The most potent external stimulus appears to be food, starvation favouring the development of spermatozoa, while a generous diet seems to result in a majority of ova. There is no doubt that sex as such is not inherited; what is inherited is merely the power to develop into male or female.

The best example of early differentiation of the germ cells



ORIGIN OF THE PRIMORDIAL GERM-CELLS, AND CASTING OUT OF THE CHROMATIN IN THE SOMATIC CELLS OF ASCARIS. (Boveri.)

A. Two-cell stage dividing. B. The same from the side. C. Resulting four-cell stage, the eliminated chromatin in the lower pair of cells is clearly shown. D. Third-cleavage, repeating the process seen at A and B.

from the somatic cells is in the case of *Ascaris megalocephala* (a threadworm parasitic in the horse). It may here bem entioned that the egg of *Ascaris* has been a classical field for cytological research, and is especially associated with the names of those two really great men, van Beneden and Th. Boveri. The eggs are particularly well adapted for minute observation on account of their large size, and the clearness with which the most complex changes are defined.

In the case of *Ascaris* the differentiation of the reproductive cells from the somatic has been traced by Boveri back to the very first division of the egg. 'From the outset the progenitor of the germ-cells differs from the somatic-cells, not only in the greater size and richness of chromatin of its nuclei, but also in its mode of *Mitosis* ; for in all those blastomeres destined to produce somatic cells a portion of the chromatin is cast out into the cytoplasm, where it degenerates, and only in the germ cells is the sum total of the chromatin retained.'

The process is as follows :—Two long chromosomes are formed in each of the two cells resulting from the first division. These two cells divide, and a most striking result is at once noticeable. In the figure below at A such a two-celled stage is seen from the poles, while at B the same two-celled stage is viewed from the side of the spindle. In the upper cell of A the division is normal, the two chromosomes splitting longitudinally, the halves passing to the extreme poles of the spindle, as seen in the upper cell in B. In the lower cell a very different phenomenon occurs—the central portions of the two chromosomes are broken up into a lot of chromatin particles, which divide, and, as seen in the lower cell of B, these are the only portions of the chromosomes which are attracted to the poles of the spindle to form the nuclei after division. The massive outer ends of the chromosomes disappear in the cytoplasm and take no further part in forming nuclei. At C is seen the four-celled stage, and it will at once be noticed that the nuclei of the upper two cells are large and well defined, containing, as they do, the whole of the chromatin, while in the lower pair of cells the nuclei are pale and small, and lying external to them in the mesial plane are seen the masses of chromatin which have been cast off. At D the four-celled stage is seen with the mitotic figures of the next division.

The upper two cells show the spindles from the sides, while the lower two give a view from the poles. In the upper left-hand cell the two complete chromosomes can be seen, each divided longitudinally, while in the upper right-hand cell we see a repetition of the phenomenon of reduction, the central portions of the chromosomes being broken up into granules preparatory to being drawn to the poles of the spindle to form the nuclei of the pair of somatic cells thus formed—the swollen outer ends of the original chromosomes being cast out into the cytoplasm. The next division repeats the same process—one cell retaining two complete chromosomes, the other having the reduced amount. This occurs for five successive divisions and then stops. From the one cell possessing the two complete chromosomes the reproductive tissues develop; all the others with reduced chromatin form the somatic or body-cells. Thus 'the original nuclear constitution of the fertilised egg is transmitted, as if by law of primogeniture, only to one daughter cell, and by this again to one, and so on; while in the other daughter cells the chromatin in part degenerates, in part is transformed, so that all of the descendants of these side branches receive small reduced nuclei' (Boveri). It is evident from the above that there is a visible structural differentiation of the nuclei of the reproductive cells, which separates them off sharply from the somatic cells in the case of *Ascaris*.

Further on convincing evidence will be brought to prove that the nucleus—*i.e.* the chromatin—is the carrier of hereditary influences from one generation to another, also that the development and functional activity of every cell is dependent on the chromatin of its nucleus.

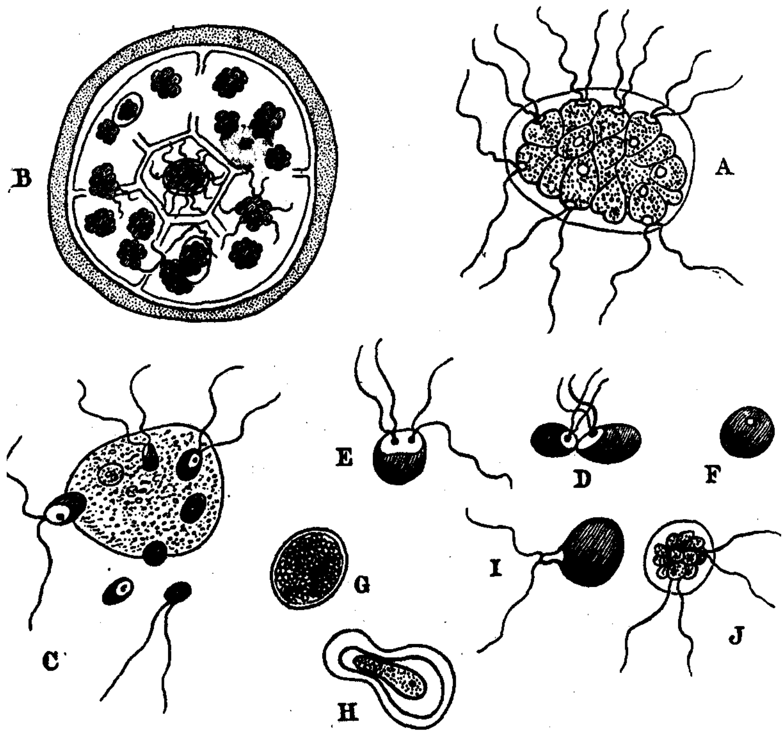
In the higher forms of plants and animals there is a sharp line of differentiation between those cells which go to form the body tissues (somatic) and those which form the reproductive- or germ-cells. It must be remembered, however, that in many of the lower forms no such differentiation exists, and a series of forms may be taken which will clearly illustrate the different grades of evolutionary steps in what must have been a very gradual specialisation of function. A rapid survey of the phenomena of reproduction in the *Protozoa* will greatly assist us in gaining a clear conception of the more intricate processes peculiar to the *Metazoa*. These lowly forms consist of a single cell, and within the limits of these microscopic structures are carried on all the phenomena of growth, nutrition, assimilation, movement, reproduction, &c. In the *Metazoa*, or many-celled forms, there is a physiological division of labour, certain groups of cells carrying certain functions, other groups other functions. In the single-celled protozoan, the process of reproduction consists simply of a division of the nucleus followed by that of the cytoplasm, the process being usually of the mitotic type. This primitive mode of reproduction continues in many forms for a number of generations, then comes the demand for a fusion with another individual, *i.e.* conjugation. Should any external influence prevent such a union, the animal shows rapid signs of degeneration which is followed by death. This weakening and loss of the functions of growth and reproduction is doubtless due to the exhaustion of the nuclear substance, for, if fresh nuclear material from a different individual be introduced, all the symptoms of senile decay disappear, and there is a rejuvenescence of the whole form.

This phenomenon is beautifully illustrated in a fresh-water infusorian called *Chilodon.* This form multiplies for some time by the simple process of transverse division. Exhaustion at last supervenes, and the necessity for conjugation occurs. The animals arrange themselves side by side, and the nucleus of each divides into two, one half remains stationary, the other half migrates to the adjacent infusor and unites with the stationary half. The two forms then separate, having received, each of them, a half nucleus from the other. After this exchange of courtesies, the two forms lead the usual solitary existence. It is very noticeable, however, that they are now charged with fresh energy, and the various phenomena of growth, reproduction, &c., are carried out with great vigour. This continues for a considerable period, until the waning energies warn the individual of the necessity for a fresh conjugation.

No one can doubt that this necessity for conjugation is the demand for a fresh supply of nuclear substance (chromatin) from another individual, and in all cases where the exchange has been accomplished the results are the same—a complete rejuvenescence of all the animal functions. Neglect to conjugate results in certain death.

In bacteria and their allies the process of conjugation does not occur, but in the great majority of simple forms the cyclical phenomena above described maintain. As we have been able to observe, in the protozoan there is no separation of cells into somatic and germinal, the organism itself consisting of a single cell, and the functions of body formation and cleavage to form a fresh generation are inherent in the one mass.

In the *Metazoa* or many-celled forms, a differentiation into body-forming and germinal-cells has taken place; the germinal-cells being isolated and quite distinct from the somatic



Development of Pandorina morum.

A. A swarming family. B. A similar family divided into sixteen daughter families. C. A sexual family, the individual cells of which are escaping from the gelatinous matrix. D, E. Conjugation of pairs of swarm spores. F. A young zygote. G. A mature zygote. H. Transformation of the contents of a zygote into a large swarm-cell. I. The same, free. J. A young family developed from the latter. (After Pringsheim.)

cells, and carrying within their chromatin rods the great function of the preservation of the race: the line of germ-plasm, from which the germ-cells arise, dates back to the very commencement of life on our planet. The somatic cells carry out their functions for a short time, become old, and die. They represent, and form the mortal portion of the individual, the body—which after all is only an excrescence growing out like a bud from the immortal line of germ-plasm, and which soon ceases to exist; the germ-plasm, however, continuing on and on, and possessing within the intricate structure of its chromatin the power of producing new individuals, and thus preserving the race from extinction.

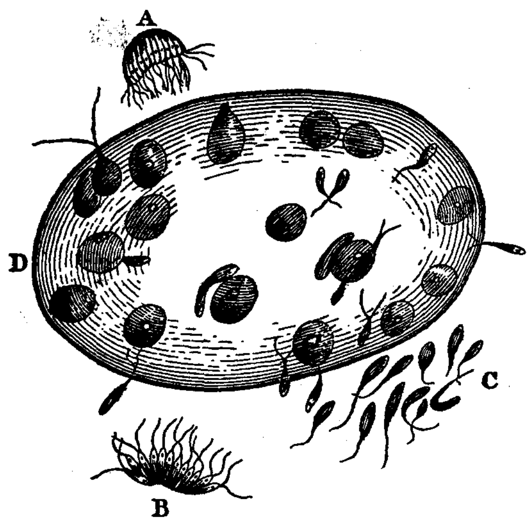
Between the *Protozoa* and *Metazoa* there is, as we have seen, a very marked difference in regard to the process of multiplication. In that neutral territory, however, between unicellular and multicellular organisms, there exist certain colonial forms, which in the modes of reproduction show a series of beautifully graded steps, which link up almost imperceptibly the protozoan and metazoan forms.

For instance, in *Pandorina morum* we have a freshwater alga which consists of sixteen cells, resting in a gelatinous matrix. From each of these sixteen cells two long flagellæ project out into the water, and by the concerted lashing of these living oars the colony is able to move about. By a process of simple division each of these cells divides into sixteen daughter-cells; the gelatinous matrix in which they are embedded dissolves, and sixteen daughter-colonies are set free. This process is repeated for several generations until exhaustion occurs, and the necessity for conjugation is felt. The sixteen cells forming a colony divide, each cell into eight, and these are set free by solution of the surrounding envelope. These swarm-spores consist of an oval cell, the pointed end being clearer than the rest, and carrying a pair of hair-like processes, which by their vibrations cause the spore to move about. Supposing the spores of one colony come near those of another they unite in pairs. The united pair form a more or less spherical cell which develops around itself a cellular envelope. It then passes into a resting stage. It may continue in this state of dormant vitality for a considerable length of time, but, on meeting with suitable conditions, *e.g.* moisture and warmth, the outer envelope bursts, the contents escaping in the form of a large swarm-spore, which soon divides into sixteen cells to form a new colony.

In the case of *Eudorina elegans*, a form closely allied to

Pandorina, there is a very great difference in the size of the conjugating swarm spores. In *Eudorina* there are sixteen or thirty-two cells embedded in a gelatinous matrix. Each cell divides by successive cleavages into sixteen or thirty-two cells, thus forming a new colony, which becomes free from the parent one.

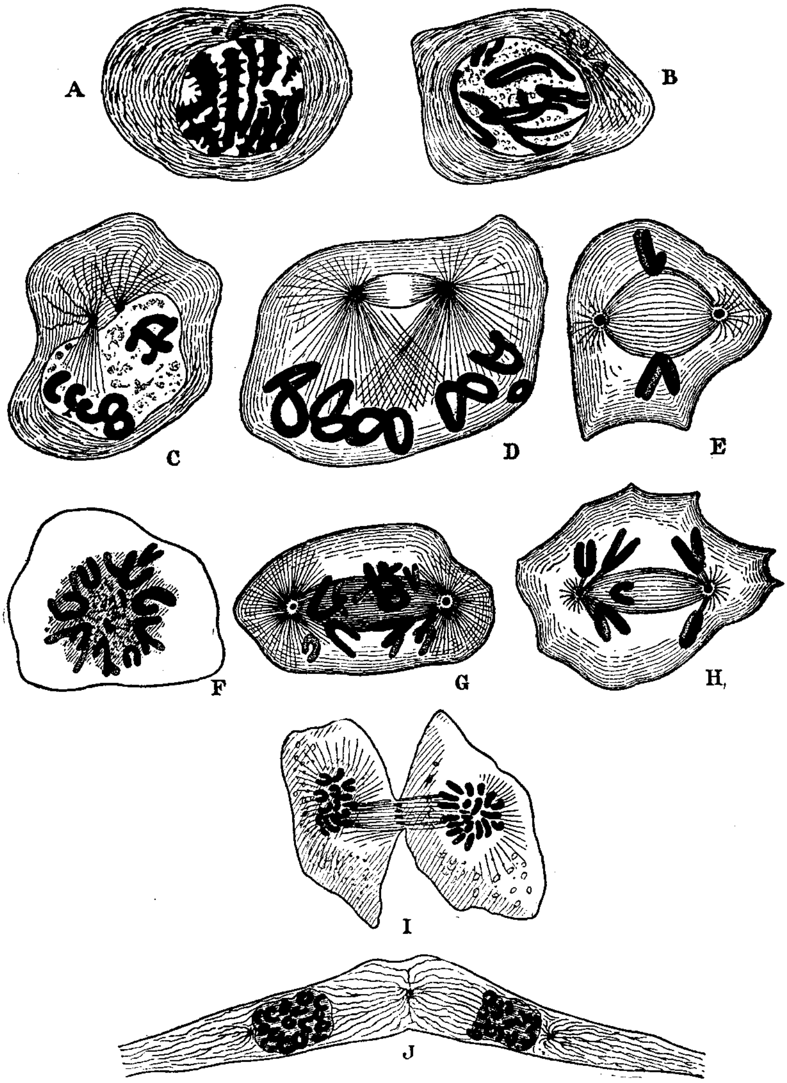
The process of conjugation shows a marked difference,



EUDORINA ELEGANS.

A female colony around which antherozoids are swarming. A. Mass of antherozoids still united. B. Cluster of antherozoids just separating. C. Swarming antherozoids, some of which have penetrated into the female colony D. (After Goebel.)

because the colonies become differentiated into two kinds—male and female. With regard to the female colonies, the cells are altered into egg-cells or oospheres without any further division. In the male colonies, each cell divides into sixteen or thirty-two antherozoids, which are elongated cells, each one being furnished with two hair-like processes attached to its anterior extremity. Should a colony of antherozoids come across one of oospheres, the antherozoids at once separate, pierce the envelope, and find their way to the egg-cells. One antherozoid blends with one oosphere, and the conjugated



THE PROPHASES OF MITOSIS IN PRIMARY SPERMATOCYTES OF THE SALAMANDER. (Meves.)

A. Early segmented spireme, two centrosomes are seen outside the nucleus. B. Longitudinal splitting of the spireme; and appearance of astral rays. C. Early amphiaster and central spindle. D. Chromosomes, nuclear mempair forms a compound cell or zygote, around which an envelope is formed, and from which a new colony of sixteen or thirty-two cells develops.

There is yet a third stage in the process of differentiation of the uniting reproductive cell, and this is beautifully illustrated in the case of *Volvox globator*. *Volvox* consists of a hollow spherical colony, the cells being arranged in a single layer, and being connected together by cytoplasmic processes. As the time for reproduction approaches, the most profound changes take place in some of the cells. Some increase to a great size, and contain in their substance stored-up food material; these enlarged cells become the egg-cells. Other cells divide into masses of very minute antherozoids. The rest of the cells of *Volvox* remain in a state of inactivity, and finally die. At this moment it is well to note that the cells forming the *Volvox* colony become differentiated into two great classes: (1) somatic- or body-cells; and (2) reproductive- or germ-cells: this early foreshadowing of a differentiation into body- and germ-cells in *Volvox* persists, as we have already seen, in a more elaborate and accentuated form in all the multicellular plants and animals.

To return to the fate of the antherozoids and oospheres. One antherozoid fuses with a single oosphere, and the resulting compound cell or zygote develops at a later date into a fresh colony.

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brane disappeared, mantle-fibres forming, and attaching themselves to the chromosomes.

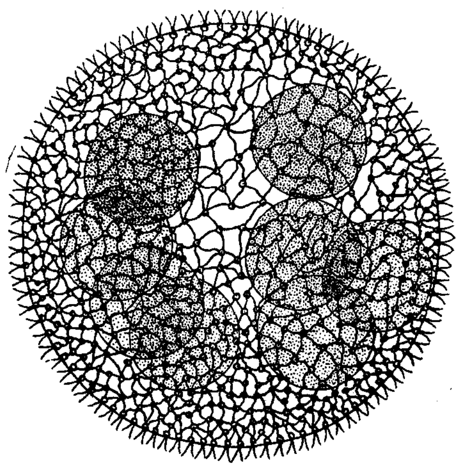
METAPHASE AND ANAPHASES OF MITOSIS IN SPERMATOCYTES OF THE SALAMANDER. (Drüner.)

E. Metaphase. The central spindle-fibres pass from pole to pole of the spindle. Outside them a thin layer of mantle-fibres attached to the divided chromosomes, of which only two are shown. Centrosomes and asters well seen. F. Transverse section through the mitotic figure, showing the ring of chromosomes surrounding the central spindle, the cut fibres of the spindle showing as dots. G. Anaphase, divergence of the daughter-chromosomes, exposing the central spindle. H. Later anaphase. Central spindle fully exposed; mantle-fibres attached to the chromosomes. The cell now divides immediately—see next figure.

FINAL PHASES OF MITOSIS IN SALAMANDER CELLS. (Flemming.)

I. Chromosomes at the poles of the spindle, the body of the cell dividing. J. Cell immediately after division; daughter nuclei re-forming, a centrosome just outside of each. The central granule is the mid-body.

A great host of unicellular forms could be quoted as examples, showing every gradation as regards size of the conjugating cells—from those in which sperm and germ are equal, to such a form as *Volvox,* in which there is a marked difference in size between the oosphere and the antherozoid, the egg-cell being large, heavily laden with food material and incapable



VOLVOX.

Showing the small ciliated somatic cells, and eight large germ cells. (Drawn from life by Emerton.)

of movement, while the antherozoid is much smaller, its cytoplasm is greatly reduced, and it is highly mobile.

In multicellular forms there is a continuation of the same phenomena. The egg contains a large supply of food stuffs. For its development conjugation with a sperm cell is necessary. The sperm cell is the spermatozoon, which is exceedingly minute in size, consisting of a nucleus, centrosome, and a very small amount of cytoplasm, which is differentiated into an organ of locomotion in the form of a tail. It is quite evident there is a physiological division of labour between the two conjugating cells. The egg from its size has lost the power of movement, while the sperm, much reduced in size, is admirably adapted for rapid and long journeys.

In the highest forms these two conditions are most marked. Various stages of these modifications are met in the unicellular world, as already seen in *Pandorina, Eudorina,* and *Volvox.* In the case of *Pandorina* the conjugating cells are practically equal in size, in *Eudorina* an intermediate stage is witnessed, while in *Volvox* we have a marked differentiation both in size and mobility between the germ and the sperm. In the first two all the cells are vegetative, afterwards becoming reproductive ; in *Volvox,* however, we have one of the earliest indications of a definite separation, from the first, of somatic- or body- from reproductive- or germinal-cells.

SOME NOTES ON THE GAME ANIMALS OF JUBALAND

By I. N. Dracopoli

Although Jubaland cannot boast of the quantity or variety of game found in other parts of the East African Protectorate, yet the study of those animals that are encountered within its borders cannot fail to interest the traveller, and this is especially the case with the race of Grant's gazelle and the zebra, that inhabit the more open districts of the country lying between Kismayu and Birkau to the west of the sandhills, and Hunter's antelope, which roams through the scrub-covered wilderness that stretches between the Tana and the Lak Dera. In the following notes I shall confine myself to a short description of these three animals, specimens of which I obtained myself in Jubaland.

Hunter's antelope belong to the sub-family *Bubalidinæ,* and constitute part of a small group of ruminants known as 'Bastard Hartebeestes,' to which also belong the Topi (*Damaliscus corrigum*) the bontebok (*D. pygargus*), the blesbok (*D. albifrons*), and the tsessebe (*D. lunatus*). They are closely