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THE TRANSITION FROM THE INDIVIDUAL TO THE SOCIAL LEVEL[1]

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THE self-sustaining biological individual in its most elementary, non-social condition is seen in the free single cell. I shall deal with such free single cells, known as Protozoa, and shall try to trace the various directions in which there is transition in their activities from the individual to the social level. I shall deal mainly with those Protozoa which are known as ciliate infusoria.

As criteria of social action several points or relations are distinguishable. First, in any grouping of organisms, are the individuals influencing each other? Second and perhaps more important is the question of the functional value of the relations of the individuals: are there relations of mutual benefit, of cooperation in the performance of necessary biological activities? (In some cases the functional value is negative; the individuals harm each other.)

Third is the question of functional differentiation, of division of labor among individuals that are reaching socially. This is perhaps equivalent to the question whether there exists social *organization*. Only if the individuals play different functional roles is there social organization.

Social behavior commonly manifests itself in the

[1] Symposium on "Levels of Integration in Biological and Social Systems. Group or Population Aspects," University of Chicago, Tuesday, September 23.

aggregation of individuals, or sometimes in its opposite, dispersal; in the fact that the individuals of a species tend, for whatever cause, to remain together; or that they tend to separate.

A free cell, such as the infusorian Paramecium, without companions and without aid performs the fundamental activities of life; those connected with nutrition; movements and reactions, reproduction.

One of the fundamental activities relieves it of its solitary condition. It reproduces, it divides into two. Each of the two divides, and this continues till many individuals are present.

But the world is wide; such individuals may separate, exercising no influence on each other. In many cases they do separate widely, each remaining at the individual level.

On the other hand, in some cases division of the individuals is incomplete, so that the individuals remain materially connected, forming what is called a colony. Development in this direction is to be treated by another speaker in this symposium; I shall therefore not pursue it, but deal with social relations only among individuals that separate completely, remaining free.

Such free individuals may influence each other in various ways. One of the most fundamental of these relations lies in the fact that they affect each other's reproductive processes. When two or several individuals are together, each may reproduce by division more rapidly than does the single individual alone. A functional relation has arisen, a social relation of mutual benefit.

Such phenomena were first described by Robertson in 1921. He made observations which, he believed, prove that in some species of infusoria multiplication occurs more rapidly when other individuals of the species are present. It seemed that the individuals must secrete materials which pass into the water and stimulate other individuals to reproduce. This phenomenon Robertson called the allelocatalytic reaction.

Some later investigations have failed to confirm the occurrence of such effects. Others supported the views of Robertson[2] (see the reviews of investigations in this field by Allee[3]). The great complexity of the biological environment in Protozoa makes difficult the attainment of concordant results in this field. Changing one factor in the environment changes others, so that the results of a single changed factor can be known only with great difficulty. Also it is possible or probable that different species differ in these phenomena.

But the recent critical investigations of Mast and Pace[4] and of Kidder,[5] making use of sterile cultures, yield the conclusion that in the organisms studied (Chilomonas and Tetrahymena) the so-called allelocatalytic effects are real. The organisms named are shown to modify the medium in which they live in such a way as to cause somewhat more rapid multiplication in individuals of their own kind that are present. When, however, the number of individuals in the medium becomes very great, the rate of multiplication is decreased instead of increased. How generally such phenomena occur in Protozoa is not yet known. There are strong indications that in some other infusoria similar effects are produced in a less direct way.

So far as this method of action occurs, it lends significance to the aggregations of individuals, however these aggregations are produced. When many individuals of a species are gathered together they promote each other's reproductive processes; they cause the species to increase and multiply; or in some cases they have the opposite effect.

We must therefore examine the phenomena of aggregation in our infusoria. Aggregations are produced in many ways.

One method is through common reactions to given stimuli. The free individuals produced by division of a single parent are alike, in their structure and in their physiology. Therefore they react in the same way to outer agents. In some species all swim toward a source of light. In an electric current all swim toward the cathode. All may tend to move against the force of gravity. In most species, all the individuals tend to bring their bodies into the fullest possible contact with small solid objects. These common reactions tend to keep the cells together; they produce aggregations. Protozoa of a given species may often be collected in thousands by allowing the light to fall on them from one side, or by passing an electric current through the fluid in which they swim, or by so placing them that their relation to the pull of gravity is constant. The cells then form dense aggregations. In these aggregations there is no integration save the common reaction to an outer agent. There is no differentiation of function among the individuals, no division of labor, no organization. Of mutual influence there is only the increased or decreased tendency to multiplication, resulting from the presence of many individuals together. Possibly also this coming together through a common reaction presents an opportunity for social organization to arise.

At a similar low level are aggregations which are produced as a result of the fact that the conditions for multiplication are the same for all the members of the species. Where nutritive conditions are good,

[2] T. B. Robertson, *Biochem. Jour.*, 15: 612–19, 1921.

[3] W. C. Allee, "Animal Aggregations," 431 pp., Chicago, 1931; *Biol. Reviews* (Cambridge), 9: 1–48, 1934; "The Social Life of Animals," 203 pp., New York, 1938.

[4] S. O. Mast and D. M. Pace, *Physiol. Zool.*, 11: 359–82, 1938.

[5] G. W. Kidder, *Physiol. Zool.*, 14: 209–26, 1941.

multiplication occurs, so that dense aggregations are formed. Such nutritive aggregations are exemplified by the multitudes of parasitic Protozoa found within the body of the host. In these nutritive aggregations there need be no functional differentiation of individuals, hence nothing resembling a social organization.

Returning to the aggregations resulting from motor reactions, one may observe in these a step forward, in that the individuals begin to react to each other, even to cling together. At the lowest level the individuals react to each other merely as to other physical masses. As before remarked, in many infusoria the individuals react to any small loose bodies, such as bits of filter paper, by placing themselves as fully as possible in contact with them. The infusoria are themselves small loose bodies, so that they react in this way to each other. On touching they may remain in contact, forming small dense aggregations. In these aggregations there is still no functional differentiation, no division of labor, no social organization. Though the individuals react to each other, each one plays toward the others merely the role of a small solid object.

In some of the Protozoa—particularly in the ciliate infusoria—this reaction of individuals to each other reaches a higher development, which is of a striking character. The reaction to other individuals becomes specialized, both in its object and in its character. Two individuals that happen to touch remain in contact and move together in a coordinated manner. They swim off in a coordinated motion side by side, proceeding in a graceful spiral through the water. "They may keep this up for but a few seconds, then separate, or may continue it for a much longer time, leading finally to a mating of the two. Most often, however, this caressing behavior lasts but a few moments, then the two individuals separate—possibly coming together again in a similar way a few seconds later."[6] This type of behavior has perhaps implications that are much higher than those of the behavior thus far described. It plays a role in the processes of mating, which are to be described later.

Now comes a more advanced stage of development. The individuals in many species react to each other's chemical properties, and they react in a specific way, such as keeps them together. Chemicals of certain sorts diffuse from their bodies into the water, inducing in other individuals reactions that give rise to close aggregations.

This is a great step in advance. Through it the individuals react to each other without actual contact; they react at a distance. It provides some of the most striking phenomena in the life of single-cell organisms. Many infusoria, such as various species of Paramecium, produce a secretion that is of a faintly acid reaction. This secretion diffuses from the individuals into the water, forming a zone of faintly acid solution. Other individuals coming into this acid zone swim about within it, but refuse to leave it. On coming to its boundary—to a region of marked decrease in acidity—they turn back. They perform what I called in my early work the "avoiding reaction," and this results in their remaining within the acid region. Every individual that comes into the acid region refuses to leave it, so that an aggregation is formed. And the more individuals there are present, of course the more pronounced becomes the acid reaction resulting from their secretions. The effectiveness of the material therefore becomes greater, so that the aggregation of individuals becomes continually denser and larger.

The aggregation is the result of negative reactions. The animals do not react when outside the region of acid, nor do they react when they enter it. But they do react when they arrive at a boundary at which they would leave. Here they react negatively, so as to remain. The dense aggregation thus results from negative reactions.

In Paramecium and some other infusoria the secretion which acts in this way appears to be carbon dioxide. If a bubble of carbon dioxide is introduced into water containing the organisms, they form an aggregation about it just as they do in the groups that are spontaneously formed. We know independently, of course, that the cells produce carbon dioxide in their respiratory processes. Also, chemical indicators show that the water in which the spontaneous aggregations occur has such a degree of acidity as would be induced by the presence of a small amount of dissolved carbon dioxide. The evidence is strong that carbon dioxide is the active agent in producing the spontaneous aggregations. They likewise collect in other weak acids.

In some other species of infusoria other secretions are produced, which likewise cause aggregations. The cells of these species will not aggregate in the secretions from Paramecium, nor in solutions of carbon dioxide. And Paramecia will not gather in the aggregations formed by these other species. Thus different kinds of cells have specific secretions, which induce aggregation in the species that produce them, but not in other species. For details of all these reactions, my early book (1906)[7] may be consulted.

In the production of such aggregations, then, the individuals influence each other. They are themselves

[6] H. S. Jennings, SCIENCE, 92: 539–46, 1940. Also: Leidy memorial lecture, 17 pp., The University of Pennsylvania Press, 1941.

[7] H. S. Jennings, "Behavior of the Lower Organisms," 366 pp., New York, 1906.

the agents in producing the aggregations. But nothing is known as to any functional value of these aggregations, of any reciprocal benefits to the individuals, save for the probability, already discussed, that by remaining associated in groups, they influence each other's rate of multiplication. Also, there is no differentiation of function among the individuals, no division of labor; thus no social organization.

In my youth I had certain adventures with these striking aggregations. Led by the considerations just mentioned, I plumped for the conclusion that these are not social phenomena. For this conclusion there fell upon me one of those philosophers who sum up wisdom in the maxim that "Everything is true of everything." Professor A. H. Lloyd cited my conclusion as a crass example of the failure of men of science to perceive what is under their noses. These phenomena, from his point of view *are* the social phenomena of infusoria. The analysis of the behavior into its elements and the discovery of the agents that bring it about do not alter the fact of the social nature of the behavior; they merely define the character of social behavior in these organisms.

There was perhaps justification for this criticism. These phenomena may be considered one of the lowest stages in social behavior, though hardly in social organization. And social organization actually does exist in these organisms; to this I shall come presently.

We have to this point dealt with (1) aggregations formed through common reactions to external conditions, though the organisms do not influence each other; (2) with cases in which the individuals influence each other, through the production of secretions that form solutions in the water, and that result (in some cases at least) in the formation of aggregations of many individuals. In some cases the mutual influence is of functional value, in other cases this is not known to be the case. In none of these cases is there differentiation of function among the individuals, so that there is no social organization.

A genuine social organization with differentiation of functions does however occur in the infusoria. In connection with what we may call family relations, functional differentiations appear among the individuals, and there is consequently a more or less complex social organization.

I have recently given accounts of the principal features of this organization[6, 8] so that I shall here limit myself to an outline of its conspicuous features.

In the biparental reproduction of the ciliate and flagellate infusoria, two individuals partly or completely unite, and from these are descended by fission a new set of vegetative generations. In the flagellates the two individuals coalesce into a single zygote, and the zygote produces the new vegetative generations. In the ciliates the two individuals, which we shall call the parents, do not completely coalesce, but become incompletely united and while in this condition exchange halves of their genetic or hereditary materials —their chromosomes; then the two separate. Thus each individual fertilizes the other. After separation each is a new combination of chromosomes, and each now multiplies in the usual way by fission—the new generations receiving half of their chromosomes from each of the two parents (the two conjugants). It is in connection with these processes that social organization has arisen.

It turns out that the two individuals which mate are differentiated, somewhat as the two sexes are differentiated in higher organisms. In the Protozoa, however, the differentiation is physiological, not, so far as one can see, structural. In the flagellates so far as studied (in the work of Moewus[9] and others), and in some of the ciliates, there are in any species or variety just two types that mate together, as there are two sexes in higher organisms. In some other species of ciliates there are more than two of these mating or sex types. In *Paramecium bursaria,* of which I have made a special study, there are in some varieties four mating types, in another variety there are eight. Individuals that are of the same sex type do not mate together. But individuals that belong to one of the sex types may mate with individuals of any other sex type. So in the flagellates, and in those ciliates in which there are but two sex types, A and B, every pair of mates consists of one A and one B. But in the species with four sex types, A, B, C and D, pairs may consist of $A \times B$, $A \times C$, $A \times D$, $B \times C$, $B \times D$, or $C \times D$, so that six different kinds of matings are possible. In that variety in which there are eight sex types, twenty-eight different kinds of matings may and do occur.

The actual process of mating is spectacular. When stocks of two different sex types are mingled together by mixing the cultures in which they are found, there is a sudden and strong reaction. The individuals of different sex type cling together. Several individuals of one sex type may cling to one individual of the other sex type. These are joined by other individuals of both types. In this way tight groups or clots are quickly formed, many individuals of the two types

[8] H. S. Jennings, *Genetics,* 24: 202–33, 1939; *Am. Nat.,* 73: 385–89 and 414–31, 1939. Also in: Biological Symposia, Vol. 1, 1940, pp. 117–21 and 145–63. See also: "Inheritance in Protozoa," Chapter 15 in "Protozoa in Biological Research," edited by Calkins and Summers, pp. 710–71. "Genetics of *Paramecium bursaria,* II. Self-differentiation and Self-fertilization of Clones." To be published in *Proc. Amer. Philos. Soc.* "Genetics of *Paramecium bursaria,* III. Inheritance of Mating Type, in Crosses and in Clonal Self-fertilization." To be published in *Genetics.*

[9] F. Moewus, *Jahrb. f. wiss. Bot.,* 86: 753–83, 1938.

clinging together as if their bodies were covered with glue. They thus form masses of dozens or hundreds of individuals. (The formation and growth of these masses were shown in photographs projected on the screen.)

In the clotted masses the individuals adhere firmly together as if covered by some adhesive material. The clinging together is not an active or motor reaction, nor is it brought about by organs of attachment. It appears to be a physical adhesion; any part of the body of one individual thus adheres to any part of the individual of the other sex type. Often an individual visibly struggles as if trying to escape from the attachment to another individual, but in vain.

The great clotted masses remain thus with the component individuals stuck irregularly together for some hours. Then they begin to break up into smaller clots and often into chains of individuals attached end to end. This breaking up continues for two or three hours, the clots becoming smaller, until there remain only groups of two.

Thus in the course of this long and irregular adhesion the individuals of the two sex types have paired off, so that now almost all the individuals are in pairs. In every case the two individuals of any pair are members of the two different sex types. This is easily demonstrated when the individuals of the two different sex types differ in color or in other ways, as is often the case. It is further true that at any stage in the reaction, it is only members of two different sex types that adhere together; members of the same sex type show no tendency toward adherence.

The two mates remain intimately united for twenty-four to thirty-six hours, during which time they exchange halves of their chromosomes. They then separate and each begins to multiply by fission. (This description is from Jennings, 1940,[6] with verbal alterations.)

In forming these aggregations therefore the individuals of the different sex types react to each other as individuals, not merely to physical forces or to masses or chemicals present in the environment. The individuals are functionally differentiated, react selectively; and the reactions are highly functional, resulting in bisexual reproduction and the phenomena of inheritance from two parents.

In this mating behavior a part is played by the contact reactions of individuals to each other, previously described. Two individuals that come in contact react by swimming together for some distance. If they belong to different sex types (of the same variety), the contact passes into adhesion, so that the two individuals mate and complete the processes of conjugation. But if they belong to different sex types, they separate after swimming together for a time. The contact reaction appears to have the function of a trial; if the individuals in contact are appropriate mates they unite in conjugation; otherwise they do not.

The differences between the different sex types appear to be of a chemical nature. Moewus[9] has seemingly demonstrated this for the two different sex types of certain flagellates, and has determined the nature of the chemical materials characteristic for each type; they are differing carotinoids. (For a general account of sex types and their physiology, see the résumé by Sonneborn.[10]) The conditions found in the ciliates are such as to suggest similar chemical differences in this group. The phenomena indicate that the materials characteristic for each sex type do not diffuse into the water, so that actual contact of individuals is necessary for inducing the typical mating phenomena. The chemical effects are thus surface phenomena.

Besides this differentiation into sex types, the individuals of any species may be differentiated into a number of different groups or varieties. Each group or variety has its own set of sex types, but the members of different varieties never mate together, so that the varieties remain distinct. In *Paramecium aurelia,* Sonneborn[10] finds three different groups, each with two sex types, but the groups never intercross. In some cases indeed members of the different groups are physiologically antagonistic, so that contact between members of different groups results in injury or death. We have here an example of negative social reaction; relations of mutual injuriousness between certain members of the same species.

In *Paramecium bursaria* there are likewise three varieties which never intercross. Two of these varieties have each four different sex types, while the third has eight. The system of possible matings is therefore complex. There are sixteen different sex types in the species as a whole; these mate together in accordance with the rules above set forth.

The social organization in these creatures is further complicated by the conditions of youth, maturity and age, and by the phenomena of inheritance. In *Paramecium bursaria,* after mating has occurred each of the two parents (the two ex-conjugants) produces a series of vegetative generations. The entire set of individuals, of many successive generations, produced by a single parent, may be called a clone. Each clone lives for thousands of vegetative generations, throughout several years. We may distinguish in each clone a period when it is young, when it is middle-aged, when it is old. In each of these periods the clone consists of great numbers of cells, like the body of a higher

[9] Moewus, *Jahrb. f. wiss. Bot.*, 86: 753–83, 1938.

[10] T. M. Sonneborn, "Sexuality in Unicellular Organisms," Chapter 14 in "Protozoa in Biological Research," edited by Calkins and Summers, pp. 666–709, 1941.

animal, but in the infusorian the clone is formed of separate cells, scattered in different regions.

Immediately after mating has occurred the clones produced by fission of the two parents are immature. The individuals of which the clones are formed do not react sexually at all; do not mate. This period of sexual immaturity or youth lasts for many generations, extending through months or in some cases even years. During this period of immaturity it is not possible to distinguish different sex types, since there are no sexual reactions.

After a long period, some of the individuals of the young clone begin to show a slight tendency toward mating. This period of weak and scattered sexual reactions might be called adolescence. It continues for many vegetative generations, through some weeks or longer, the tendency toward sex reactions gradually increasing.

Finally the cells of the clone become fully mature. Their sexual reactions are then immediate and strong (for an account of the striking phenomena in these reactions, see Jennings[8] or Sonneborn.[10]) At this stage it is possible to distinguish the different sex types, and to examine the relations between the sex types of the parents and of the clones that descend from them; that is, to study the rules of inheritance of the sex types. We now find that all the individuals of any clone are of the same sex type and indeed that all the individuals of the two clones descended from the two parents that form a pair are of the same sex type. But different pairs of the same cross produce clones of different sex type. By crossing many individuals of two clones, one of sex type A, the other of sex type D, we obtain among the descendants clones of all the four different sex types, while certain other crosses produced only three of the four sex types (for details, see Jennings, "Genetics of *Paramecium bursaria*," III).

The condition of maturity, with its differentiation into sex types, lasts for several years—during which time each original parent has produced through fission millions of individuals, all of the same sex type, and all equally mature.

But now, as in higher organisms, all this becomes changed through the phenomena of aging. The first indication of this lies in the fact that the individuals of old clones no longer produce vigorous young when they mate. Many of the young die. A period arrives in which conjugation results in the immediate death of all the individuals that mate; or in death of all descendants after two or three fissions or less. In this later period if a young and vigorous clone is mated with the old one, this means death to all descendants of either parent.

The effects of aging become later still more pronounced. The very old clone no longer reproduces vigorously even by fission; multiplication takes place only very slowly. Many of the individuals die. The clone can be kept alive only with great difficulty. Finally, in spite of all efforts to keep it alive, all the individuals that belong to it die. The old clone has become extinct.

This account of youth, maturity, age and death is based on what occurs in *Paramecium bursaria*. In some other infusoria, notably in other species of Paramecium, the conditions appear to be very different from those just described. The period of youth or immaturity is in *Paramecium aurelia* very short, lasting but a few days (Sonneborn[10]). There is seemingly in these other species no aging. *Paramecium aurelia* and *Paramecium caudatum* may be kept alive, and reproducing vigorously by fission for an indefinite period.[11] Whether mating continues to produce vigorous offspring in late age in these species seems not to have been determined.

The conditions as to aging and death in *Paramecium bursaria* agree with the earlier accounts given by Maupas[12] for a number of species of ciliate infusoria, and by Calkins[13] for *Uroleptus mobilis*. The nature and causes of the age changes are uncertain, but the facts as to decline in vigor and inability to continue biparental reproduction are clear. The change may be the result of living for long periods in unnatural conditions in the laboratory; or it may be of the same sort as senescence in higher organisms (whatever that essentially is).

Thus in the life of the infusoria the clone may be considered the unit, as the individual body is the unit in higher organisms. Both the clone and the body are composed of many cells; both show periods of youth, adolescence, maturity and age. In both, all the cells are normally of a particular sex type; and different clones, like different bodies, are of diverse sex types. The clone is like a body in which the component cells do not remain together, but are scattered in space and time.

The differentiations in the social system of the infusorian are based upon mating and reproduction. There appears to be nothing corresponding to the industrial organization so conspicuous in some of the higher organisms, such as in the ants, bees and man. The system is more comparable to what has been called "Society with a capital S," than to the division of labor in carrying on the work of the species.

To sum up, we find that a natural population of

[11] H. S. Jennings, *Bibliographia genetica*, 5: 105–330, 1929.

[12] E. Maupas, *Arch. d. Zool. Exp. et Gén.* (2), 6: 165–277, 1888.

[13] G. N. Calkins, *Jour. Exp. Zool.*, 29: 121–56, 1919; *Jour. Exp. Zool.*, 31: 287–305, 1920.

such a unicellular organism as *Paramecium bursaria* shows in connection with reproduction a considerable degree of differentiation and social organization. There are young immature clones, adolescents, sexually mature clones reproducing vigorously, and aged clones that no longer reproduce successfully, and that finally die. Among the mature clones, we may find representatives of the three different groups or varieties, and of the sixteen different sex types that constitute the three varieties. That is, the individuals are functionally differentiated, and react to each other in a highly selective way. In these respects the social system is complex, resembling that in some of the higher animals. The social organization connected with family life is of such a type as to form a natural step in the evolution of social systems, suggesting a unity throughout the world of organisms in respect to these matters.

To summarize the whole, we find that the transition from the individual to the social level begins in the one-cell organisms; and advances there by several steps. In connection with reproduction and development there has arisen a social organization of a considerable degree of complexity.

OBITUARY

JOHN STANLEY PLASKETT
1865–1941

WITH the passing of Dr. J. S. Plaskett, who died at his home in Victoria, B. C., on October 17 of this year, the astronomical world loses another of the men who were responsible for the rise of modern astronomy. Canada loses in him the leader who secured for her a prominent position in the astronomical world of to-day.

Dr. Plaskett was born on November 17, 1865, near Woodstock, Ontario. The financial resources of his family were meager, and for this reason Plaskett did not complete the work for the bachelor's degree until 1899, when he graduated from the University of Toronto. Plaskett was first an engineer in his home town of Woodstock and later for the Edison Electric Company, and for thirteen years he was an assistant in physics at Toronto. In 1903 he went as a mechanical superintendent to the Dominion Observatory in Ottawa, where he attracted the attention of Dr. W. F. King, the government astronomer of that time, and in 1905 he was appointed as director of the newly established astrophysical division of the Dominion Observatory at Ottawa. Plaskett entered upon his astronomical career at the age of forty.

During the eight years at Ottawa Plaskett's star rose rapidly. His proficiency in the adaption of the 15-inch refractor at Ottawa for spectroscopic research showed him to be one of the foremost designers of astronomical instruments. Through a careful design of the spectroscopic attachments Plaskett was able to photograph the spectra of unusually faint stars with the relatively small Ottawa refractor. The program for the measurement of stellar radial velocities which was initiated at Ottawa dealt especially with eclipsing binaries. During this same period Plaskett studied the rotation of the sun by spectroscopic means.

It was not long after his appointment at Ottawa that Plaskett began to feel keenly the need for a larger and more powerful telescope to carry on his spectroscopic researches. He discussed his needs with the chief astronomer, Dr. King, with whose strong support the project of a large reflector on Canadian soil was presented to the Canadian government. In 1913 the government placed Plaskett in charge of the development of the plans for a large reflector and soon the contracts were let for the mounting, the mirror and the optical work for a 72-inch reflector to be erected on Little Saanich Mountain near Victoria, B. C.

The mirror blank was poured at the St. Gobain works near Charleroi, Belgium, and the disk left Antwerp for the United States less than a week before the outbreak of World War I. The mounting was made by the Warner and Swasey Company of Cleveland and the optical work was performed by the Brashear Company of Pittsburgh. In the spring of 1918 the large telescope was put into operation. Because of his early training as an engineer, Plaskett was the ideal person to draw up the plans and supervise the erection of the 72-inch telescope.

Plaskett and his associates at the new Dominion Astrophysical Observatory lost no time in getting down to work. In a paper published in November, 1918, he writes:

> The mirror arrived at the Observatory on April 29, the first spectrum was obtained on May 6, and in the measurement of some 750 spectra secured since that date, these twelve spectroscopic binaries have been discovered.

Plaskett was the director of the Dominon Astrophysical Observatory from its beginning until his retirement at the age of 70 in 1935. The Publications of the Observatory published under his directorate by himself and his associates, Harper, Young, H. H. Plaskett (his son), Pearce, Redman and Beals, are a lasting monument to his driving effort and insight in astronomical matters.

The measurement and interpretation of stellar radial velocities was the main purpose of the new observatory. In the course of time Plaskett touched upon almost every phase of radial velocity work. A