GENERAL CONSIDERATIONS

Domesticated birds constitute a very small fraction of nearly 6000 or more species of birds. Amongst them those that have provided food for mankind (Poultry birds), are distinguished by their high rate of reproduction. The development of breeds of hens with the ability to ovulate large number of eggs and development of sophisticated feeding and management strategies with application of 20th century science haven taken the centre stage in poultry industry of various countries. The developments in the above aspects were further supplemented by the development of technology to incubate eggs without which the inherent genetic potential would not have been expressed. The development of artificial incubation technology has played a major role in this context and in the absence of which poultry production would have dependent on a maternal cycle in which hens lay 12-20 eggs, incubate them for 21 days, and rear the young ones for several weeks before returning to another phase of egg production. The period of incubation and rearing of the egg, the "brooding phase", is commonly referred to as maternal behaviour in domesticated birds. This behaviour can be delayed by frequent removal of the eggs. The expression of maternal behaviour however leads to curtailed egg production and in this context development of the leghorn breed which maintains egg production for a long period and displays maternal behaviour very infrequently was a major landmark of poultry breeding. The raising of genetically modified strains of poultry by breeding and selection that produce large number of eggs and the development of incubation technology have provided a good source of food for humans, both as egg itself and poultry meat. The egg remains an excellent source of nutrient in the human diet and it is estimated that 280×10^9 eggs are consumed annually throughout the world. Similarly, consumption of poultry meat is also raising steadily and an estimate of consumption of poultry meat per person throughout the world in 1987 had revealed a consumption rate of 3 - 10 kg in South Korea, Egypt, Sweden, Mexico and Switzerland,a rate of 10 -20 kg in New-Zealand, Japan, Taiwan, South Africa, European community, Venezuela, Brazil and Argentina and a consumption rate of 20 -30 kg in Australia, Saudi Arabia, Israel, Canada and U.S.A. To meet these two sources of food, breeder and broiler breeds of poultry had been developed. Dual purpose breeds for both egg and meat were also developed and were the major breeds of early part of 20th century.

In India, poultry farming took off as a major venture after independence as, previously it was simply a backyard venture with a few small flocks, except for a few organized farms. Egg production remained quite low till 1960's and it was gradually realized that poultry production is an important animal agriculture practice due its easy adaptability to different climatic conditions, low economic investment per unit, rapid generation time and effective growth rate and quick returns. The Government of India, in recognition increased the allotment of funds to this sector in successive five year plans: Rs/- 28 million in the 2nd five year plan (56-57 to 60-61) to Rs/- 602 million in the 7th five year plan (85-86 to 89-90). The value of poultry product went up from Rs/- 650 millions in 1961 to Rs/- 10,000 million by the beginning of 7th five year plan. If this pace of growth in poultry production is maintained, it is anticipated that it would touch more than Rs/- 35,000 millions by 2000 A.D. Major progress has been made in the field of poultry farming in India during the last four decades mainly with respect to genetic selection, nutrition, disease control, management technics and marketing. As a result, India projected as one of the first ten top countries by 1980-81 in terms of egg production. The per capita consumption of egg is nevertheless low, mainly due to non-availability of sufficient number of eggs. The egg production is to be substantially increased by 8-10 folds to be on par with advanced countries. An estimate of the per capita consumption of egg in country shows consistent increase with hardly 9.3 in 1981 to 19.3 in 1985 and 22.5 by 1990. It is likely to increase to 30 per annum by 2000 A.D. The egg production performance of India is in no way inferior compared to the average figure of World or Asia but all the states of the country are not doing uniformly well, except for states like, Andhra Pradesh, West Bengal, Tamilnadu, Kerla and Maharashtra, which together contribute to more than 50% of the egg production in the country. Other states are lagging behind and Gujarat is one of the low yielding state. In the sector of poultry meat production, the picture is quite bad, more so till 1960. With the emphasis on broiler raising, the situation is nevertheless changed. In 1979-81, India produced hardly 111,000 metric tons of poultry and by the end of 1989 the figure has raised to 240,000 metric tons, mainly due to the realisation and the resultant emphasis on broiler farming. This is evident from data on broiler population which was hardly 4 million in 1971 and increased to 150 million by 1990 (Panda, 1984; 1995). There has also been preferential increase for consumption of poultry meat when compared to other types of meat, this is indicated by the amount of poultry meat which increased from 13.1% to 15.15% of total meat production from 1986 to 1994 (Panda, 1986; 1995). This is however, far below the data of advanced countries especially with regard to per capita availability of poultry meat. The per capita availability which currently stands at 0.32 kg needs to be substantially increased.

To raise poultry to the maximum possible potential many aspects have to be tackled. Apart from breed and genetic aspects, many environmental variables such as nutrition, disease control and management practices are also important as they can interact with the genetic background to modulate an influence on the ultimate potential expressed. Though nutritional, disease control and management technics have been effectively tackled in the country, the influence of important environmental factors like light and temperature as part of management practice to maximise the genetic potential is not explored or given adequate attention in India. (Environmental lighting and temperature are the two major variables which can influence poultry productivity through neuroendocrine mechanisms.) In this respect western countries are paying increased attention on research on photoperiodic manipulation in different breeds in terms of management technics. Increase egg yield has been realized over the years by such photoperiodic manipulations in the western world. Hence, manipulation of the photoperiod of broiler breeder, laying hens and turkey breeders has been used as one of the most powerful management tools in poultry industry. (Number of aspects of reproductive potential in poultry birds can be influenced by such practices like, the age of onset of lay (AFE), the rate of lay, the timing of lay, shell quality, egg size and feed efficiency. Periods of light and dark are usually combined in three possible ways for commercial application) the most common photoschedule is the conventional lighting regimen with a single photophase (period of illumination) and a single scotophase (period of darkness) which together totals to 24 hrs, the second is the skeleton, split or intermittent lighting regime with more than one photophase and scotophase within 24 hrs, with again symmetric or asymmetric intervals, and the third is ahemeral lighting regimen with recurring periods of light and dark that in combination may be larger or shorter but not equal to 24 hrs in length. The greatest influence of photoperiod has been found to be in the immature stages and hence, employment of various schedules of above mentioned lighting patterns has been attempted successfully to increase poultry productivity in the western countries. No such experimental evaluation has been forthcoming from the Indian Sub- continent and the general poultry practice in India is to employ the lighting regime from the day of hatch, which is based on a schedule borrowed from the western management practice. There is a need to evaluate different photic schedules in the Indian breeds or under Indian conditions (Tropical) as the response to photic manipulation is likely to be altered in relation to the genetic status of the breed as well as the climatic conditions. Moreover, as light:dark schedule influence productivity by modulating neuroendocrine mechanisms, even direct hormonal manipulation are also capable of influencing sexual maturity and egg yield. This aspect involving endocrine manipulation during the rearing stage has never been attempted in any part of the world. Hence, in the present study attention has been focused on the possible effects of rearing pullets from day of hatch till 90 days of age under short photoperiod of LD 6:18 (SP) and then shifting them to normal photoperiod of LD 12:12 which together qualifies as a step-up photoschedule. Further, keeping in mind the above mentioned lacuna, the influence of mild hypercorticalism (HPR) or hypocorticalism (HPO) during the rearing stage (d0 to d90) has also been investigated. These studies have been extended further by evaluating the combinatorial effect of both SP and HPR/HPO to garner information on photoperiod-adrenal interactions in terms of maturation of gonadal axis and reproductive potential.

In order to assess the reproductive performance of the Indian RIR breed to a changing photoperiod from short to long (step-up photoschedule), the freshly hatched pullets were exposed to a short photoperiod of LD 6:18 from day 1 to day 90 and then transferred to normal photoperiod of LD 12:12. These birds (SP birds) showed an overall improved laying performance marked by significantly earlier initiation of egg laying and higher yield and better laying performance in the form of maximal monthly egg yield with higher clutch size with shorter oviposition intervals. The SP birds commenced early egg laying by 120days which is an advancement by 58 days. This advancement obtained in our present study is a significantly greater response than those recorded for ISA Brown and Shaver 288 birds by 33 days when photoperiod was changed from 8-13h at 63 days or by 18 days when the same photoperiodic change was done at 84 days (Lewis *et al.*, 1993a). The above workers also showed that the advancement was only by 6 days when the photoperiodic shift was attempted at 119 days. Apparently the above studies showed a maximum advancement when the period of exposure was 63 days and that extension of duration of SP beyond 63 days has a gradual nullifying effect. However, the present study has clearly shown a significantly greater response even after exposure of pullets to SP after 90 days. It is inferrable from this that the age at which pullets show maximum sensitivity to a step-up photoschedule is quite different between ISA Brown and Shaver 288 on one hand and Indian RIR breed on the other hand and even in other factors like climatic conditions, and intensity of light used. No other aspects of reproductive performance under such a photoschedule could be made between ISA Brown and Shaver 288 and, Indian RIR breed as the European workers have not assessed any other feature other than age at first egg. However, in the present study the SP birds laid at an average 25 eggs more than the birds which were not subjected to such an photoperiodic shift (NLD). There was also an overall improvement by 15% in terms of average egg output, per day rate of lay and the oviposition interval. The 50% egg production was attained earlier by 72 days and even the weight of eggs which was slightly lesser during the first two months, was higher from the fourth month onwards when compared to those of NLD birds. In order to overrule the possibility of differential feed consumption by different birds, this variable was kept constant by providing a known quantity of feed per bird every day to both SP and NLD birds. This dietary regimen, considered as a rationed diet was 19.4% less than the feed consumption data obtained from Government Poultry on *ad libitum* feeding schedule. This schedule not only eliminated the possible effect of feed consumption but also showed that there is no qualitative or quantitative adverse effect in terms of reproductive performance. In terms of feed consumption data, SP birds show an economically favourable feature as the productivity was 12 eggs per birds for every 2.96 kg feed consumed as compared to 3.96kg feed consumed for the same by NLD birds. Second cycle lay was totally inhibited when hens were exposed to SP at 72 weeks of age for 30 days. Even in terms of maintenance and productivity, SP birds show a significantly favourable econome viability.

The manipulation involving adrenocortical status, involving induction of mild HPR or HPO in pullets from day1 to 90 showed a tendency for slightly increased egg yield in HPR hens and a significantly lower yield in the HPO hens. Though there was no difference in the age at first egg, the termination of lay/age at last egg was slightly delayed in HPR hens, while it occurred earlier in HPO hens thereby resulting in slightly increased duration of lay in the former and reduced duration of lay in the later. The rate of lay and the mean oviposition interval were similar in both HPR and control hens, while both showed a negative trend in HPO hens. However, both HPR and HPO hens laid lesser number of small eggs compared to the control, more so by the HPO hens; so a consideration in terms of effective eggs shows the performance of HPR hens to be significantly higher and the difference in terms of total eggs gets minimized in HPO birds. A consideration of the pattern of egg lay throughout the year shows some significant manifestations in terms of the pattern of decline towards termination of egg lay. Whereas the control birds showed a precipitous drop during the last two months, the HPR hens showed a better and gradual decline. In contrast, the HPO birds which laid at more or less constant rate for eight months showed a sudden and precipitous decline in the next three months. The observed difference in egg yield seen in the three groups of birds seems to be more of reflection of the manifestation of the decline phase. Influence of HPR/HPO during the pullet stage seems to have some influence on ovarian functions as could be deduced from the laying performance in terms of average monthly clutch size and number of clutches / month (Chapter III). In view to the fact that corticosterone is implicated in adult hens in modulatory mechanisms involving the hypothalamo-hypophysial ovarian axis, the influence of corticosterone status in the pullet stage need to be studied in greater detail to understand the potential modulatory effects on hypothalamo-hypophysial ovarian axis and the consequent effects on cycle of egg laying. In contrast, the laying performance of second cycle, when the hens were rendered transiently HPR/HPO for one month between 72-76 weeks of age, showed significant effect with the HPR hens laid at an average 15% more eggs and, the HPO hens laying 22% lesser eggs. The average egg weight was also higher in the HPR hens. (This suggests that, corticosteroids have more significant influence in second cycle lay in the adult hens, and the possible impact of short term induction of HPR in laying hens at different periods can be explored profitably for increased egg yield.)

The evaluation of the influence of HPR/HPO in pullets reared under short photoperiod has revealed an additive influence of HPR on the SP induced favourable responses, on the contrary HPO tended to minimize the influence of SP. This is clearly indicated by the various features of the laying performance like AFE, duration of lay, total number of eggs laid, per day rate of lay and even oviposition intervals, all of which showed a favourable trend over and above that of SP under HPR and a slightly negative trend under HPO. The improvement shown by the HPR birds was in terms of 5-10% and the negative influence shown by HPO was between 5-12%. Apparently, HPR in the pullet stage has a synergistic effect on the SP induced changes while HPO has an antagonistic tendency to that of SP. Even in terms of feed consumption, HPR birds seems to be more economical as they consumed 1kg/bird less feed owing to the early termination of lay, while HPO birds consumed 1.5kg/bird more due to slightly delay termination of egg lay. The SP induced cessation of egg lay in adult hens (Chapter III) was not overcome by either superimposed HPR/HPO. Apparently, a SP toward the end of egg lay has a significant influence on HHG axis and has a dominating cumulative effect on the photorefractory adult birds.

The egg constitute an ideal component of human diet, as it provides all the essential micro. and macronutrients. It is considered as an excellent source of proteins and vitamins, with also adequate quantity of lipids and minor amount of carbohydrate. In this respect, the chemical composition of the egg is of greater relevance and as such this aspect is likely to vary in terms of breed, management practices, quality and quantity of feed provided etc. The formation and deposition of these micronutrients in development of egg are due to the metabolic activities of liver, ovary and oviduct, and are influenced and regulated by neuroendocrine principles. In this respect hormonal manipulation of birds are likely to have impact on chemical composition of eggs. Moreover, the photoperiodic manipulation and various photic schedules that are being worked out for different breeds of poultry can also affect the overall composition of egg due to the effect of photoperiodic conditions on central neuroendocrine mechanisms. (Hence in the present study the impact of photoperiodic manipulation and/or induction of HPR or HPO during rearing stage of pullets has been assessed in terms of the physical and chemical characteristics of eggs produced by such birds.)

Though there are some alterations in physical and chemical components of the eggs from early to late phase of lay due to the SP manipulation, the overall changes in this respect on an average basis does not have much effect of photoperiod. However, there is a definite increase in protein content on a percentage basis as well as an overall higher lipid and cholesterol content. These changes contribute to a higher nutritive value in SP eggs by 14% over those of NLD birds (Chapter IV).

Transient chronic mild HPR or HPO in the rearing stage have certain subtle influence on metabolic features in the adult condition in relation to reproductive functions. The eggs of HPR hens, in general, showed increased protein and glucid contents and decreased lipid and cholesterol contents in the albumen and increased lipid and cholesterol contents in the yolk. These changes have been discussed in chapter V and are reflective of increased hepatic lipoprotein synthesis and qualitatively altered lipoprotein metabolism in the oviduct. Moreover, the calorific value of the HPR eggs on a 100gm edible egg basis was higher by 27%. In contrast, the eggs of HPO hens showed significant alterations in yolk and albumen content during early to late phase of lay reflecting an overall favourable influence on the protein loading capacity of the oviduct and a dampened effect in terms of hepatic protein turnover during vitelogenesis. There also appears to be higher lipid turnover in the liver of HPO hens as reflected in the yolk lipid content. Though there is no qualitative change in the hepatic lipoprotein metabolism, there seems to be increased turnover of cholesterol and non- cholesterol lipids. Obviously, chronic HPR or HPO in the immature stages have a definite influence on the lipoprotein metabolism of liver and oviduct in the adult condition as reflected by the protein and lipid contents in the yolk and albumen of their eggs. The of HPR and HPO condition under SP has no significant overall effect on neither egg composition nor on the calorific value of the eggs. However, the composition of protein, carbohydrate and lipids do show some subtle variations during the laying period which are either additive or antagonist to the changes induced by SP. There were also some unique effects other than that induced by SP and these are discussed in detail in chapter VI.

The experimental evaluations involving SP, HPR/HPO and even a combination of SP and HPR/HPO, did have subtle differential effects on the overall growth of the body as well as the growth of liver, thyroid, adrenal, lymphoid organs(spleen, thymus and bursa) and ovary and oviduct. Though there was a generalized correlation between corticosterone and growth of lymphoid organs there were nevertheless differential effects on a monthly basis during the three months of experimental manipulation which suggest differential dose and durational effect of corticosterone and growth of different organs. The growth rate and growth index of various organs were not strictly correlatable with the absolute levels of corticosterone or thyroid hormones. Apparently, under the experimental paradigm employed, there seems to be a complex interaction of the hormones and altered homeostatic hormonal balances with even altered sensitivity. There is a need to evaluate the possible subtle neuroendocrine interactions as well as target sensitivity and altered dynamics of hormonal balances in terms of synergistic or antagonistic influences under such experimental schedules as employed in the present study to have a better understanding of the differential manifestations. However, the histological and histometric studies of the ovary to a greater extent do reflect the characteristic influences of the experimental manipulations on the hypothalamo-hypophyseal ovarian axis. Based on the observations in various species of birds and even in the domestic hen, Sharp (1993) had suggested a hypothetical scheme on the influence of photoperiods on the hypothalamo-hypophyseal axis as related to ovarian growth and functions. As depicted in figure 1, the hypothalamus contains a biological clock, which measures the passage of photoperiodic time. If the photoperiod is increased, two types of input to the gonadotrophin releasing hormone (GnRH) neurons are activated, one stimulatory and the other inhibitory. The stimulatory input is fully activated immediately after photostimulation but the inhibitory input develops more slowly. If the photoperiod is decreased, the stimulatory input disappears immediately leaving the inhibitory input, which dissipates gradually after several weeks or months of exposure to short days.

Based on the present histometric observations on the ovary in relation to SP or under a condition of superimposed HPR/HPO on SP, a hypothetical model of the possible effects of these experimental manipulations on the reproductive axis in the pullets stage is proposed as depicted in the following sets of figures.

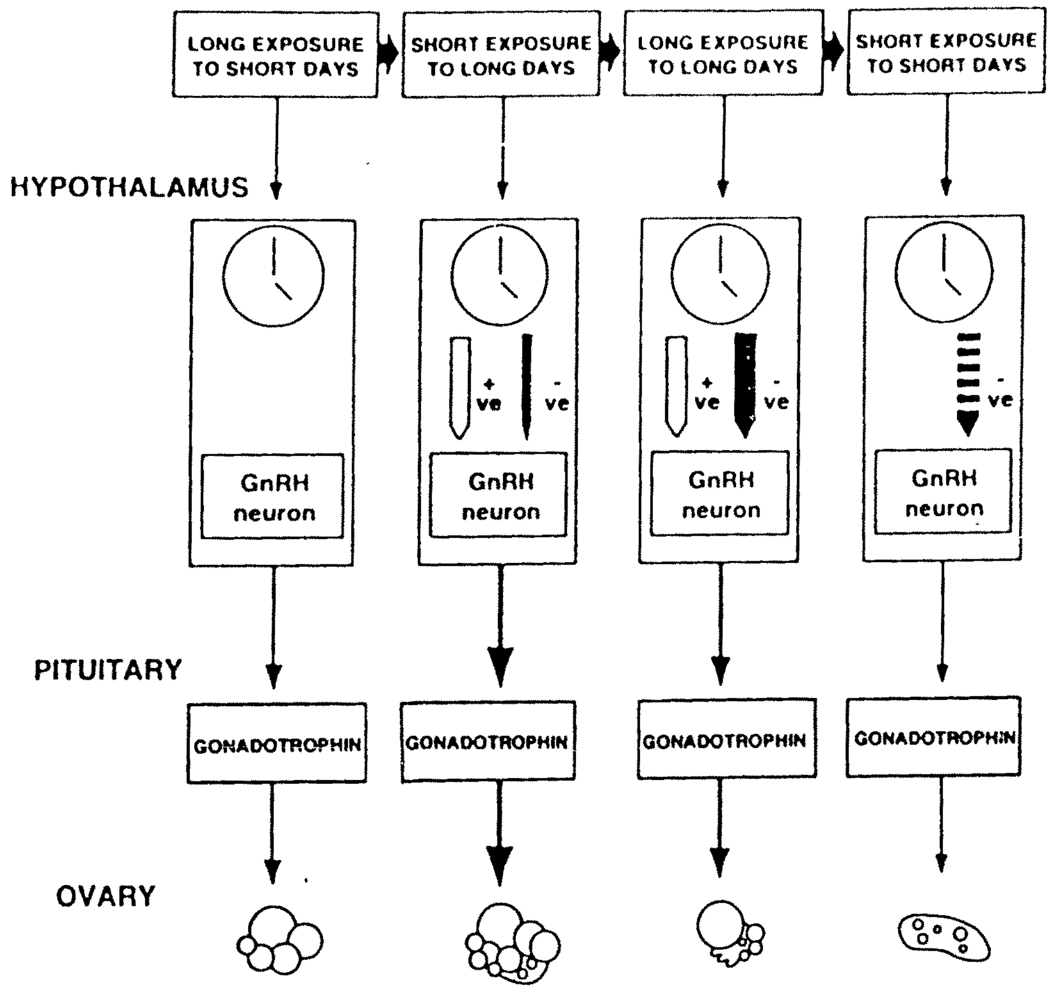


Fig :- 1- A schematic representation of the photoperiodic response of birds. The hypothalamus contains a biological clock, depicted as the face of an analogue clock, which measures the passage of photoperiodic time. If the photoperiod is increased, two types of input to the gonadotrophin releasing hormone (GnRH) neurons are activated, one stimulatory (+ve, white arrow) and the other inhibitory (−ve, black arrow). The stimulatory input is fully activated immediately after photostimulation but the inhibitory input develops more slowly. If the photoperiod is decreased, the stimulatory input disappears immediately leaving the inhibitory input, which dissipates gradually after several weeks or months of exposure to short days (indicated by broken arrow). Photoperiodically induced changes in the inputs to GnRH neurons result in the secretion of GnRH and the gonadotrophins, indicated by the thickness of the solid lines with arrows. Changes in gonadotrophin secretion control the development of the ovary (shown here) or the testes. From Sharp (1993).

Diagrams. 1, 2 and 3:

Schematic representation hypothesizing the influence of NLD, HPR and HPO on the HHG axis in pullets.

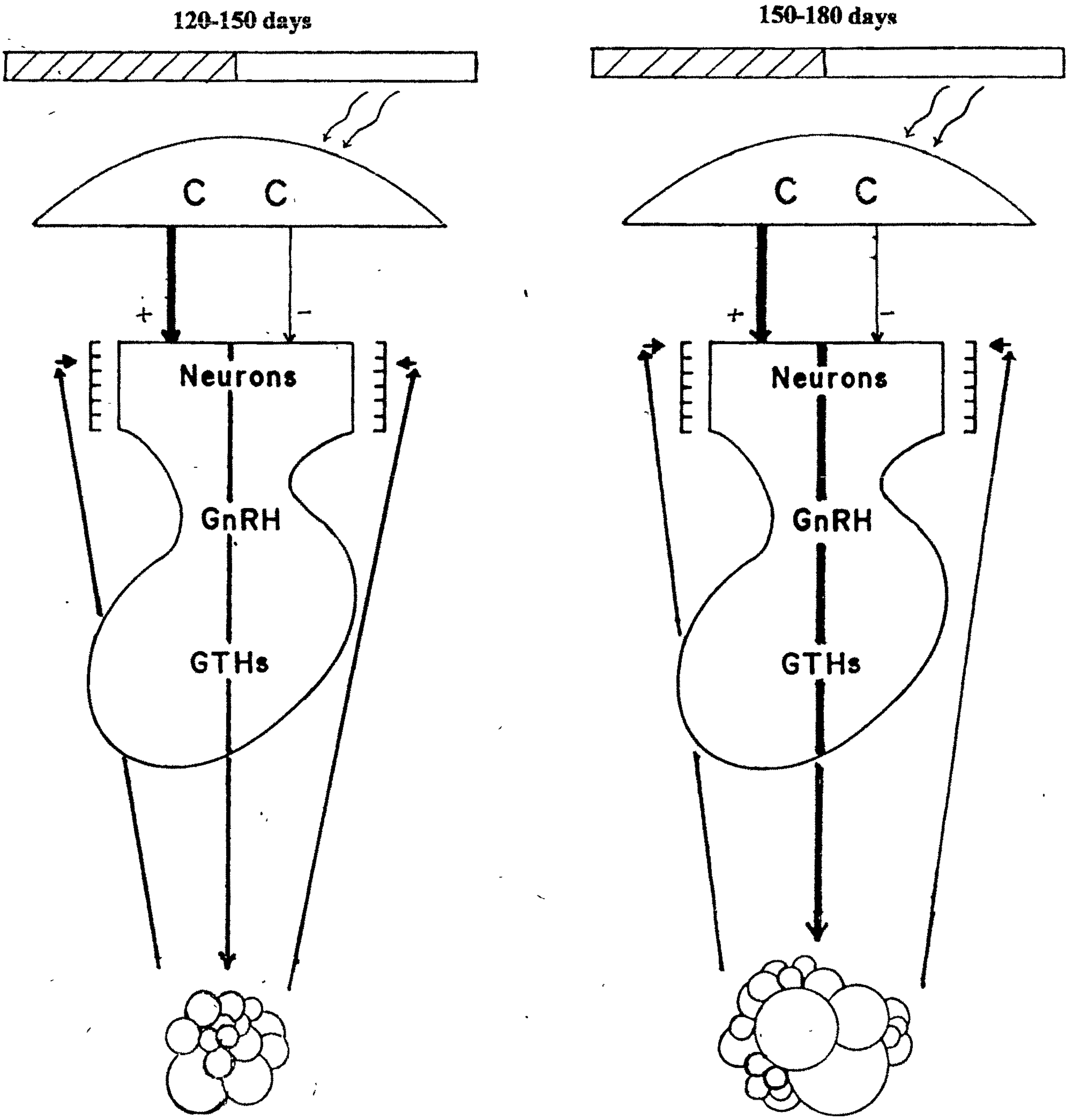
The schema presented purports to have no significant influence of either HPR or HPO on the slow gradual positive and negative inputs to the GnRH neurons from the controlling centre under normal photoperiod of LD 12:12. HPR nevertheless has a direct favourable influence in the ovary potentiating the actions of gonadotropins.

Diagarams 4,5 and 6 :

Schematic representation hypothesizing the influence of , HPR and HPO under LP.on the HHG axis in pullets.

the schema purports gradual slow increase of both positive and negative inputs to the GnRH neurons under a short photoperiod from day 1. the positive input is relatively stronger from 1-60 days, but continuous SP strengthens the negative input between 60 and 90 days. Ovarian growth is stimulated between 1 and 60 days, not only due to the increasing stimulation of the HH axis, but also by the weakened negative feed back action of gonadal steroids due to the raised threshold level of the feed back centre. The exposure to a long photoperiod at the end of 90 days makes the sensitized GnRH neurons to respond vigorously by releasing greater amount of GnRH leading to faster growth and maturation of ovary and early initiation of egg laying.

[Note 1. Prior exposure to SP probably seems to sensitize GnRH neurons for a vigourous response to a subsequent LP]


120-150 days
C C
+
−
Neurons
GnRH
GTHs
150-180 days
C C
+
−
Neurons
GnRH
GTHs

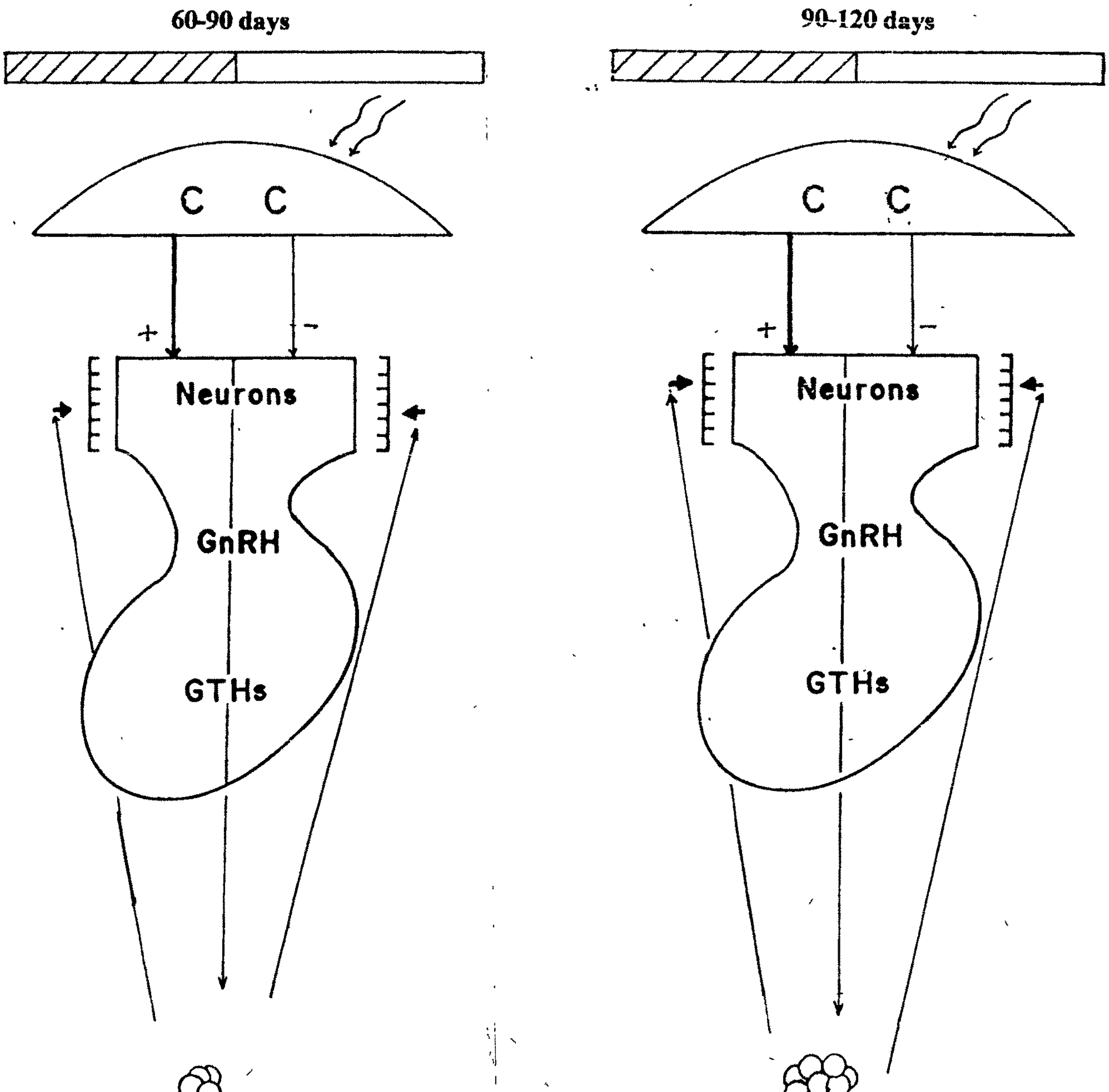
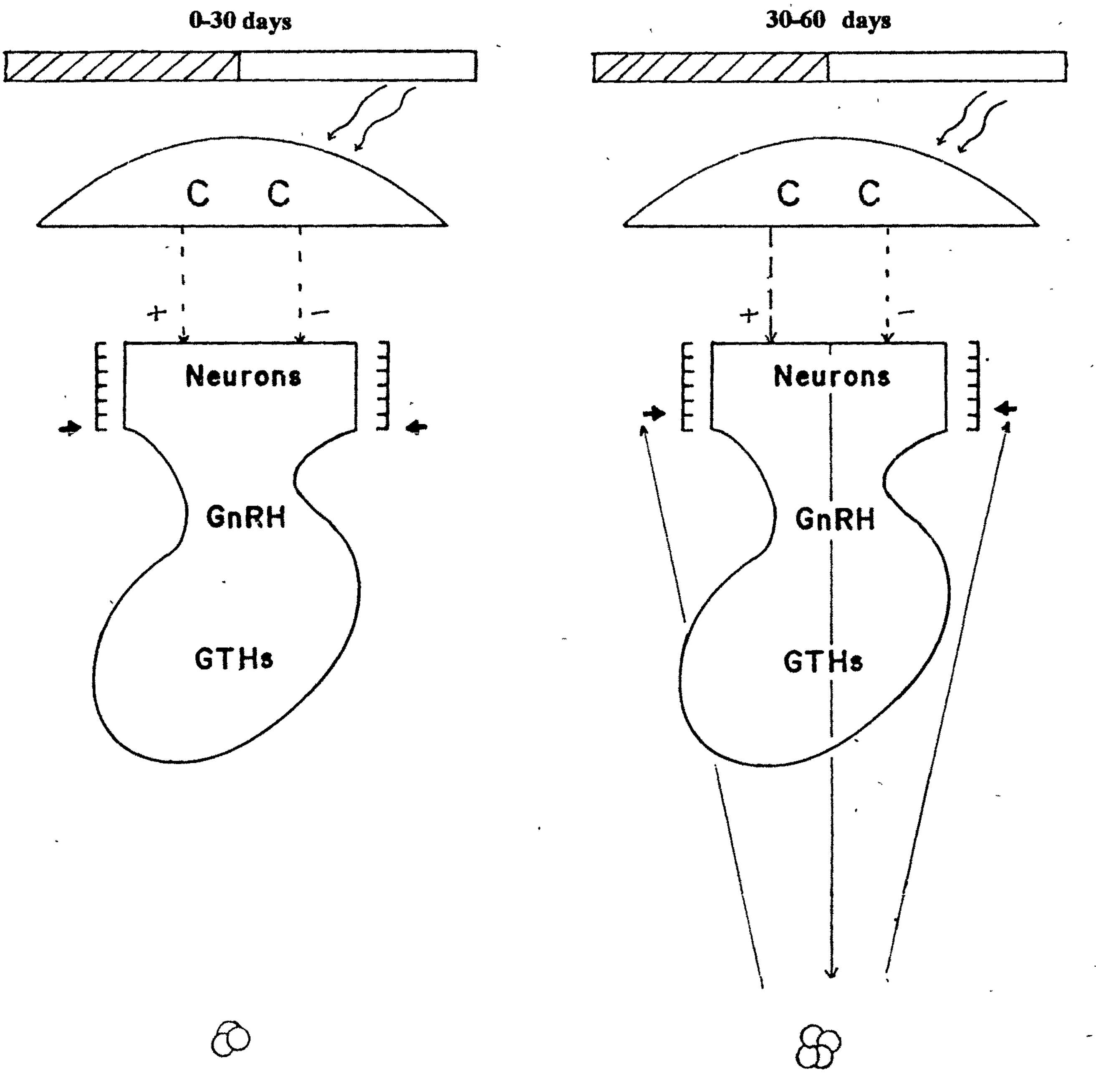
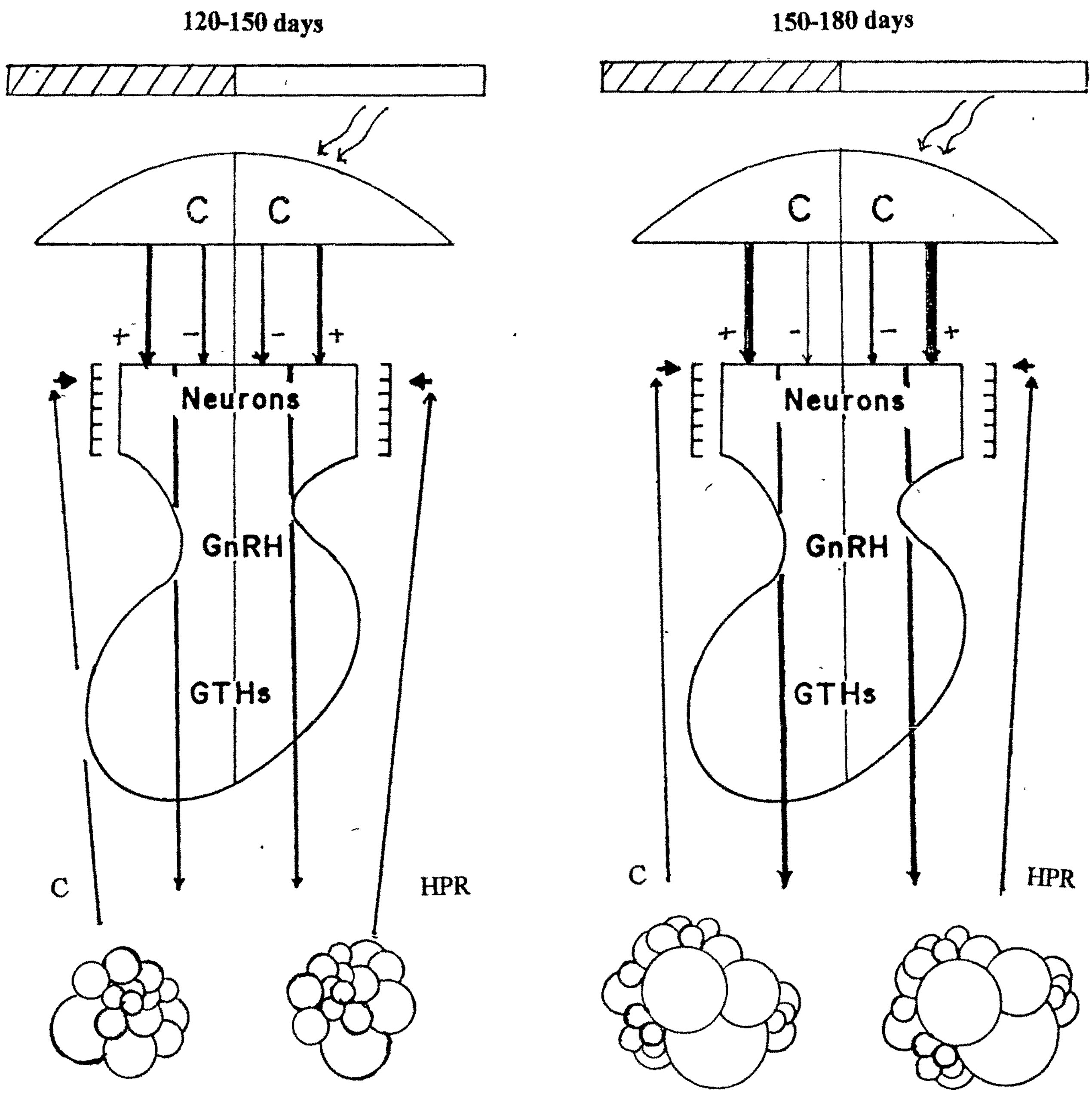

60-90 days
C C
+
-
Neurons
GnRH
GTHs
90-120 days
C C
+
-
Neurons
GnRH
GTHs

Diagram 1





120-150 days
150-180 days
C
C
+
−
−
+
Neurons
GnRH
GTHs
C
HPR

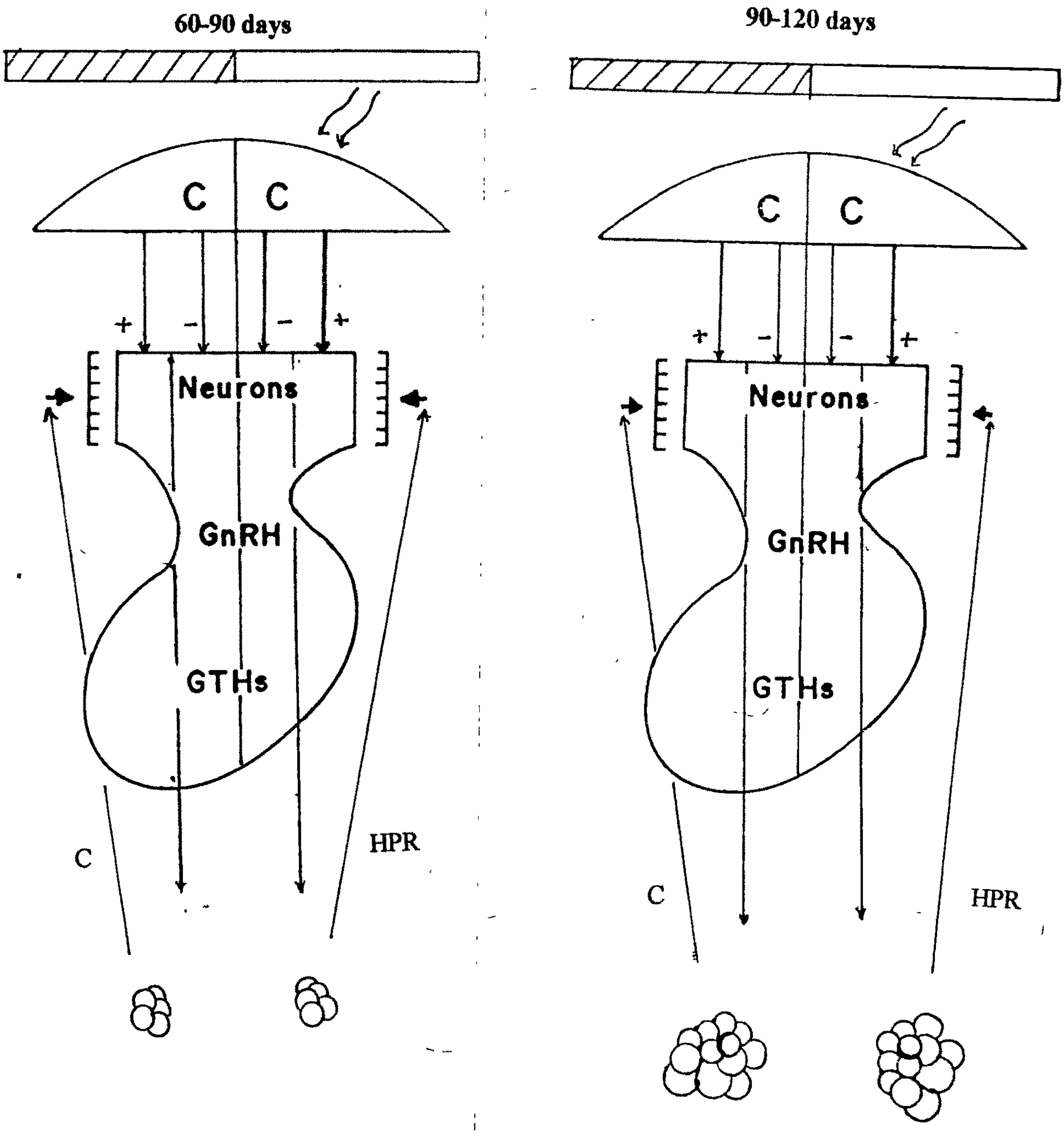
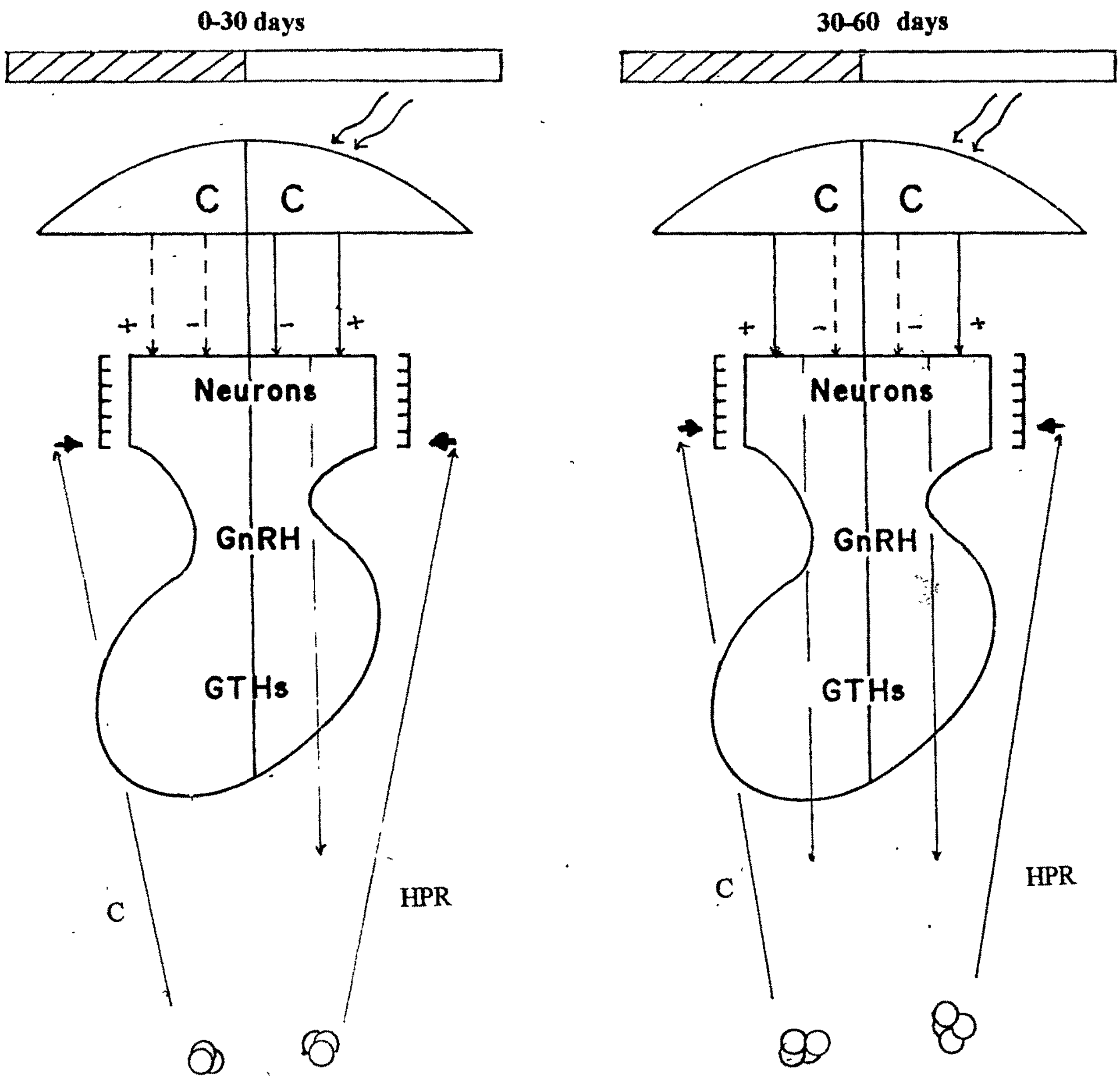
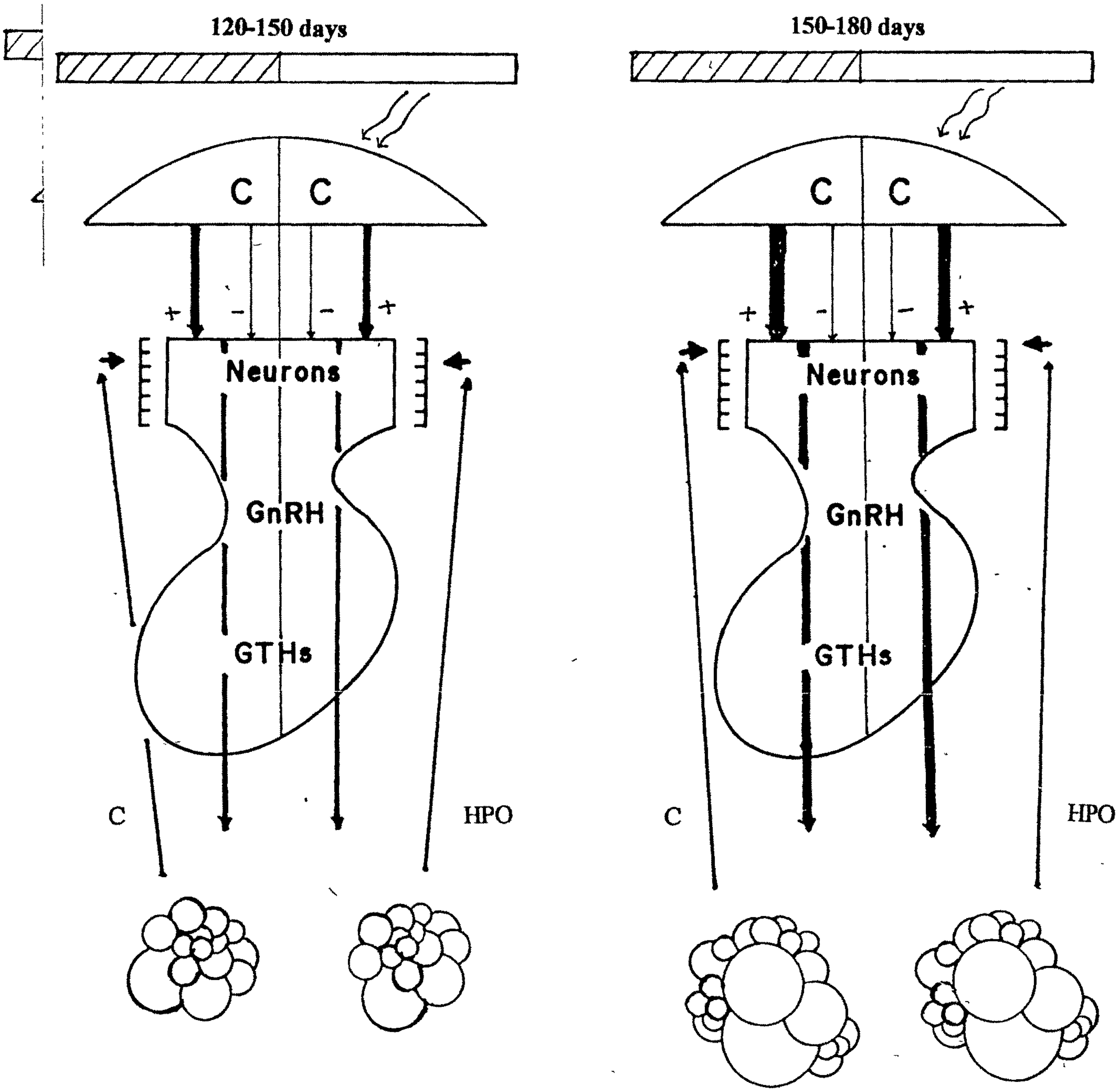

60-90 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPR
90-120 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPR

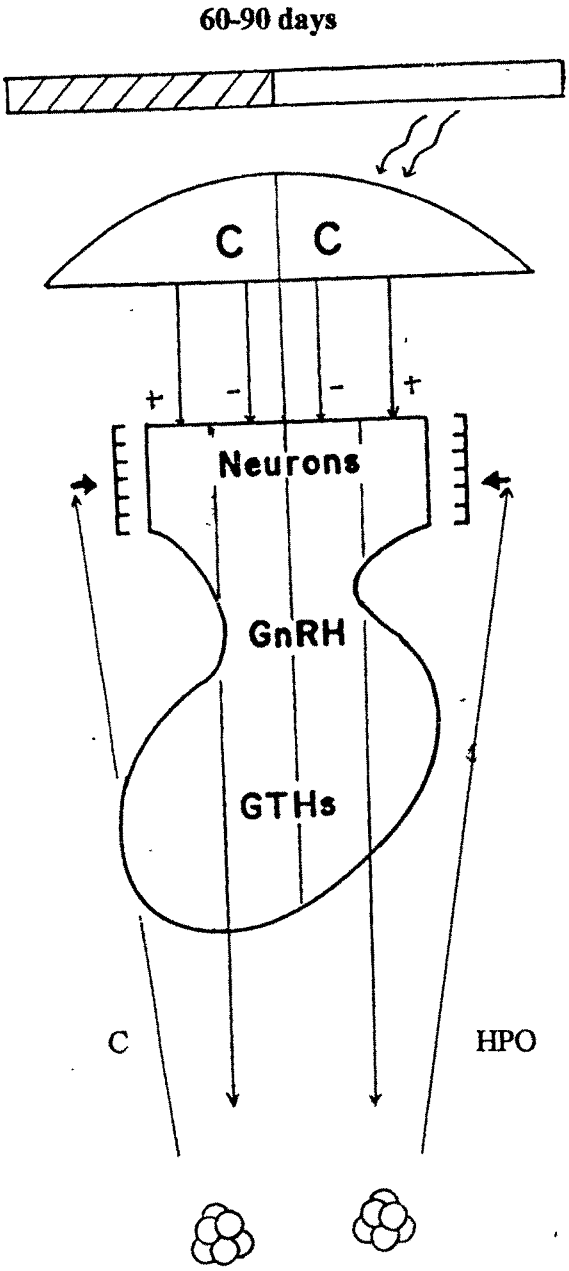
Diagram 3

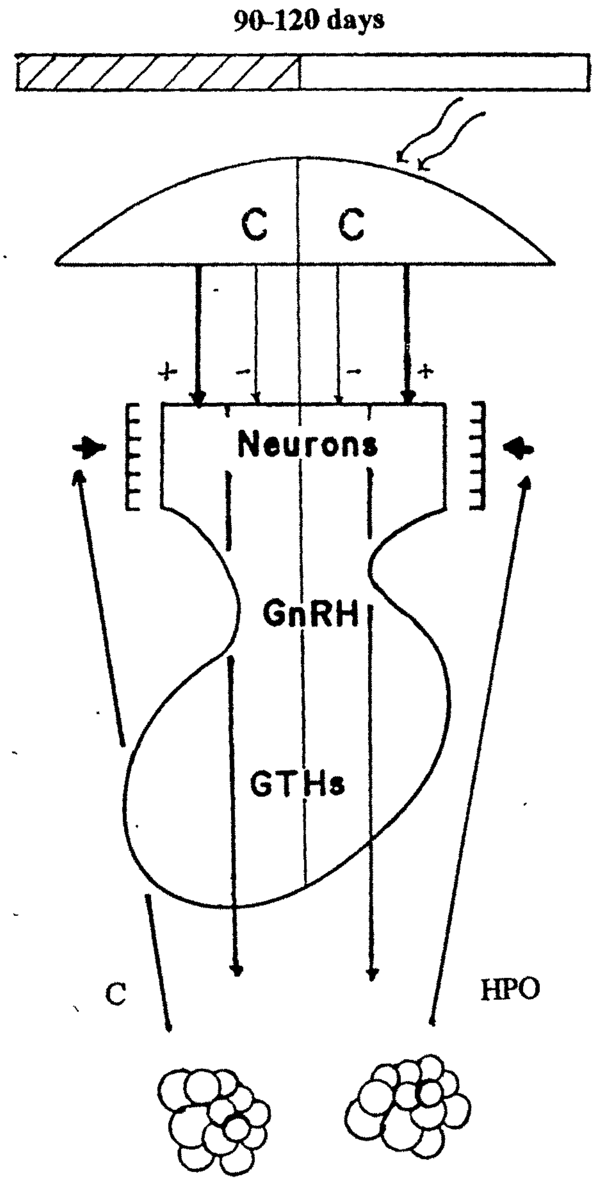


0-30 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPR
30-60 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPR

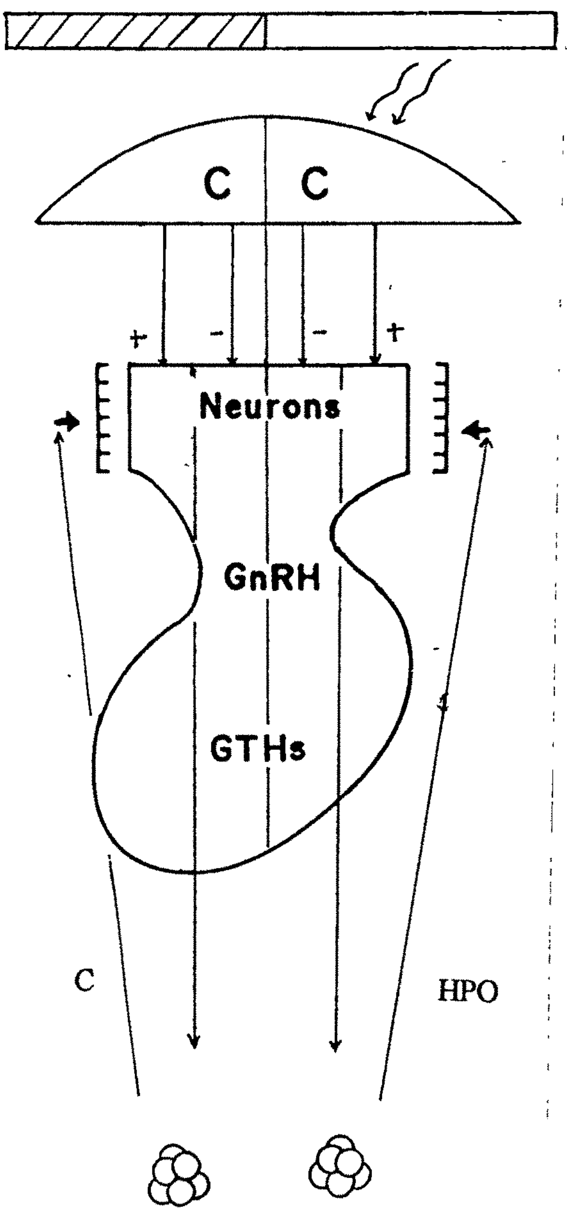


120-150 days
150-180 days
C
C
C
C
+
-
-
+
+
-
-
+
Neurons
Neurons
GnRH
GnRH
GTHs
GTHs
C
HPO
C
HPO


60-90 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPO


90-120 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPO

60-90 days



90-120 days

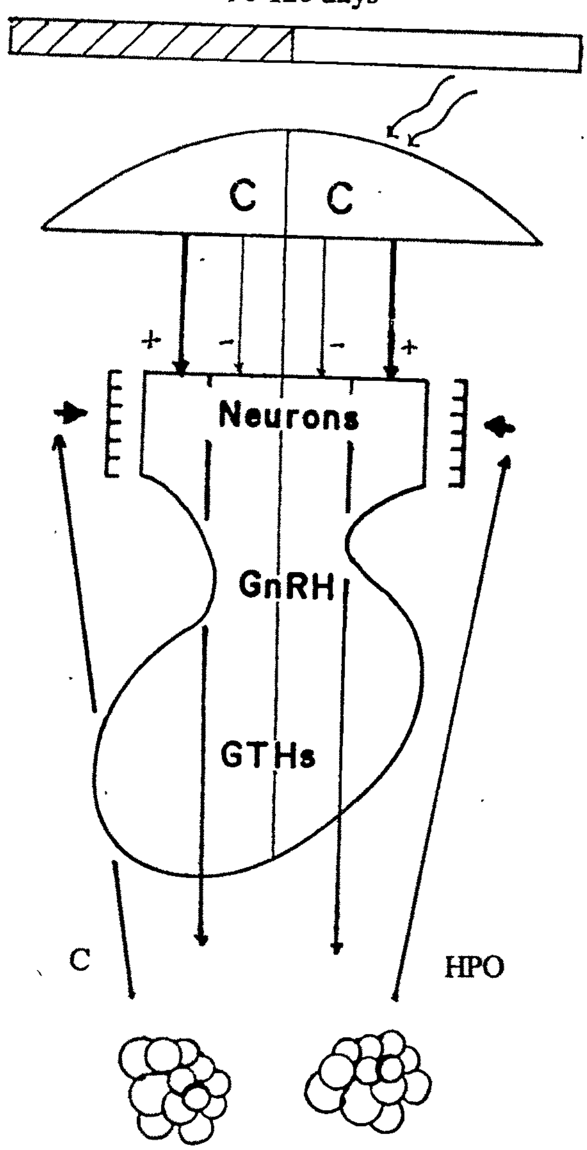
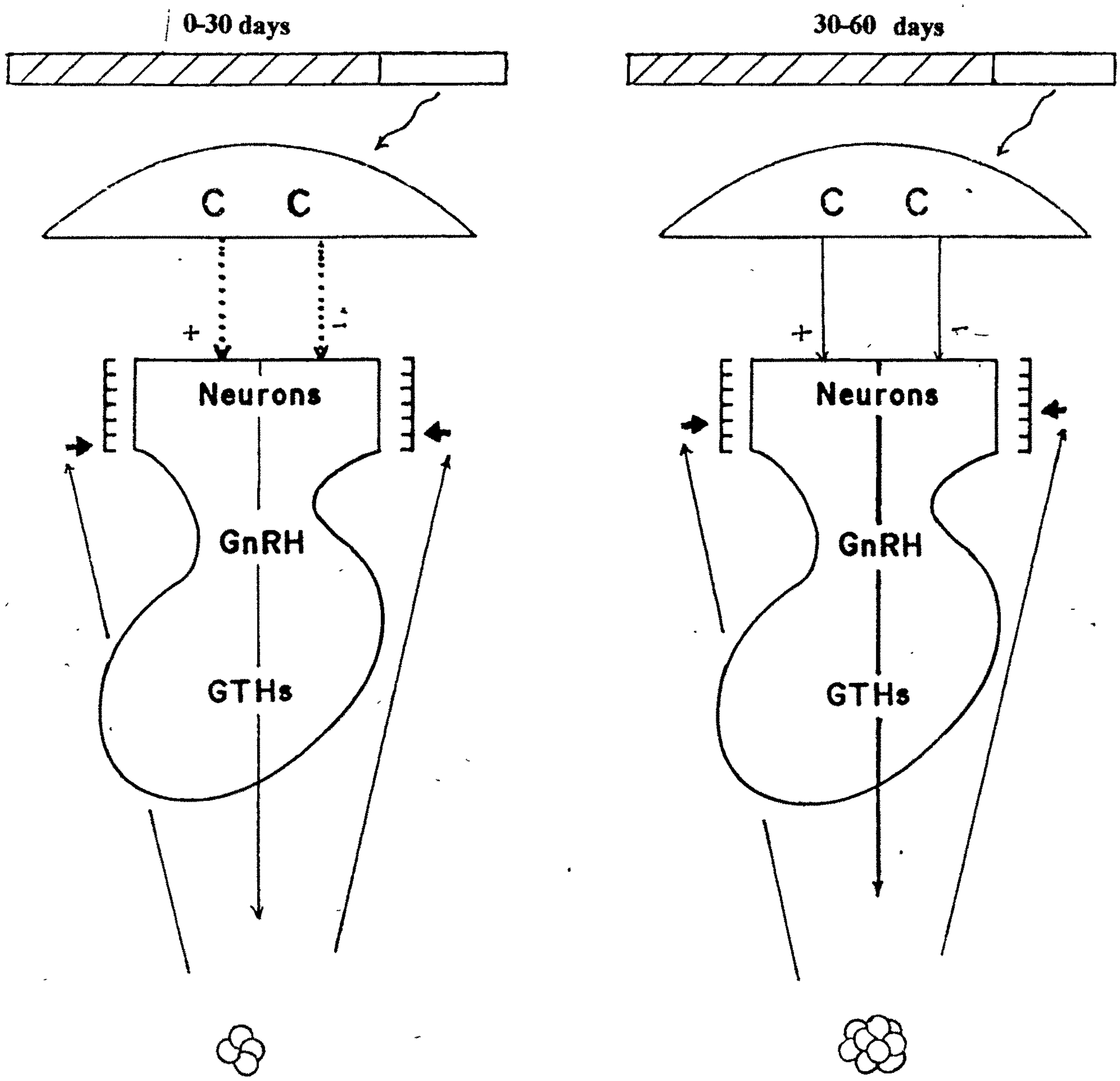


Diagram 4



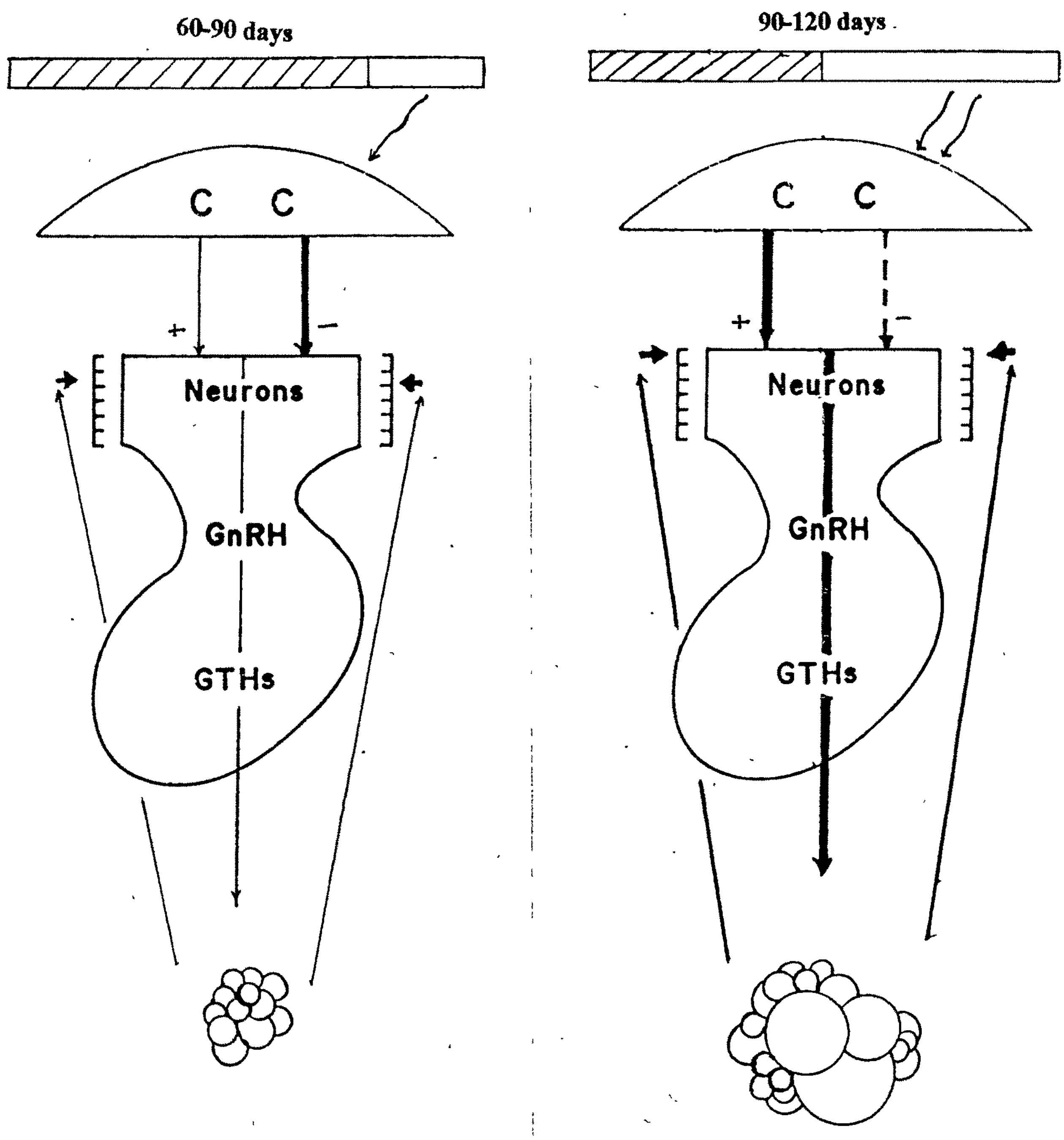
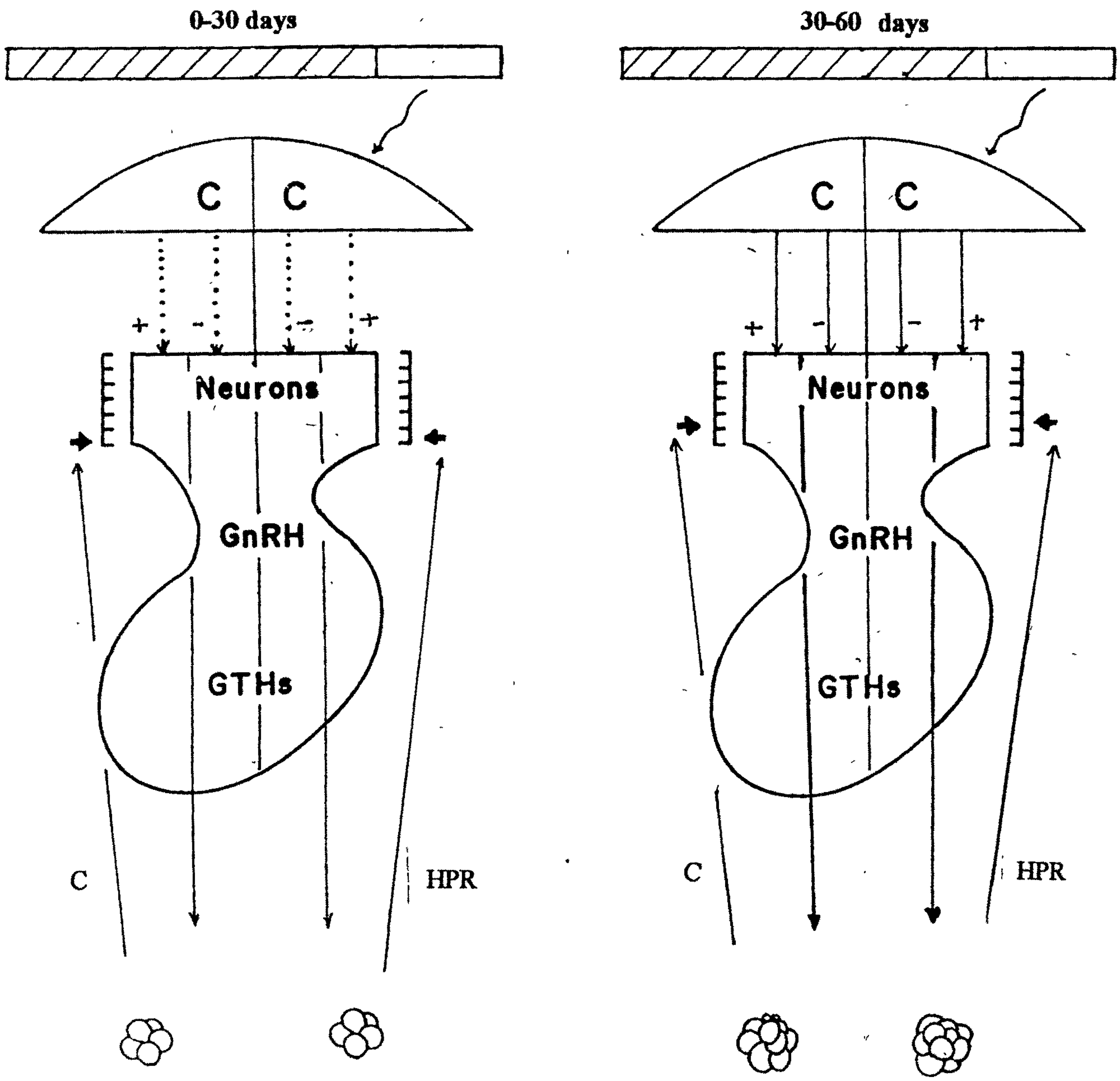

60-90 days
C C
+
-
Neurons
GnRH
GTHs
90-120 days
C C
+
-
Neurons
GnRH
GTHs

Diagram 5



0-30 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPR
30-60 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPR

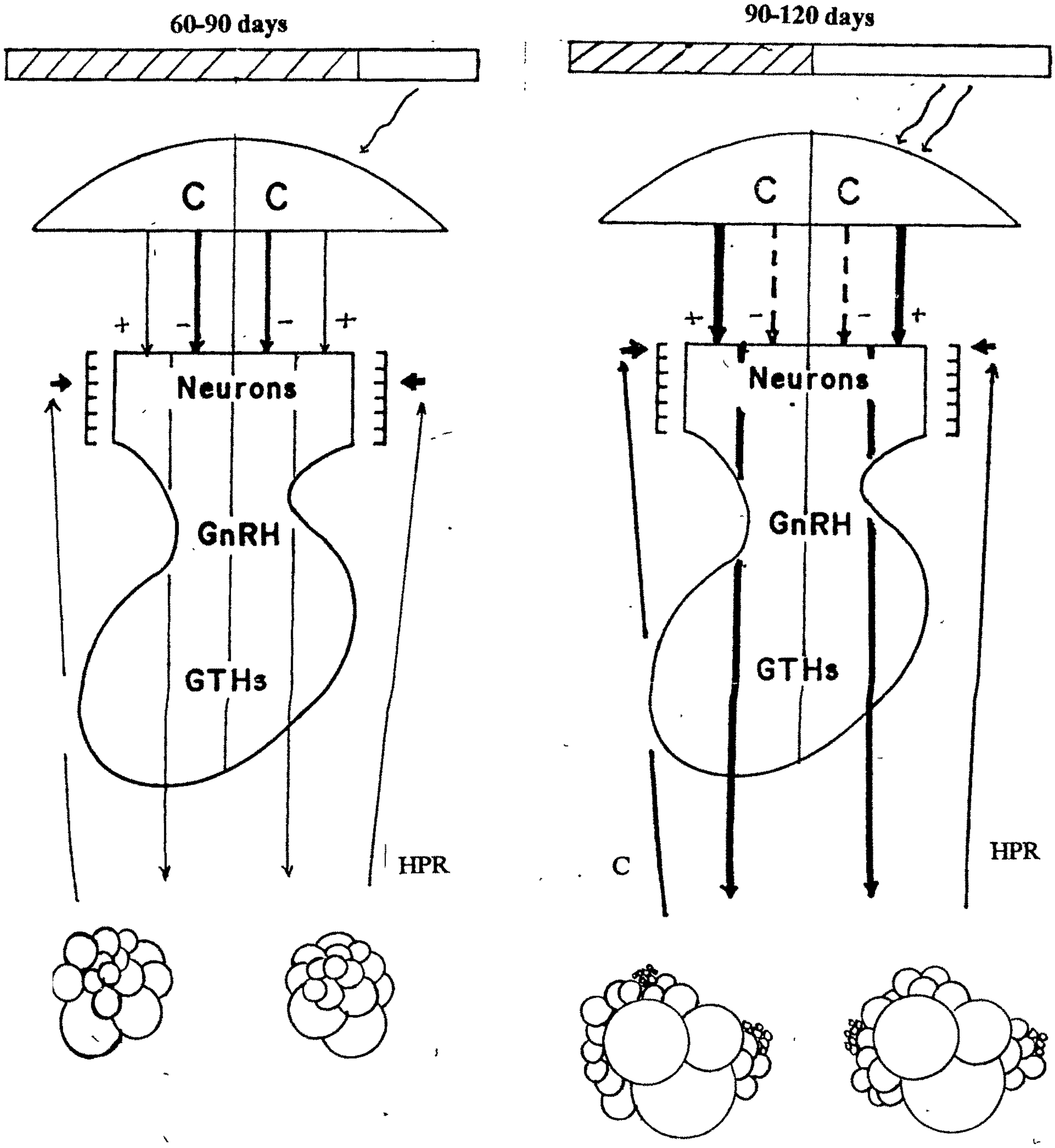
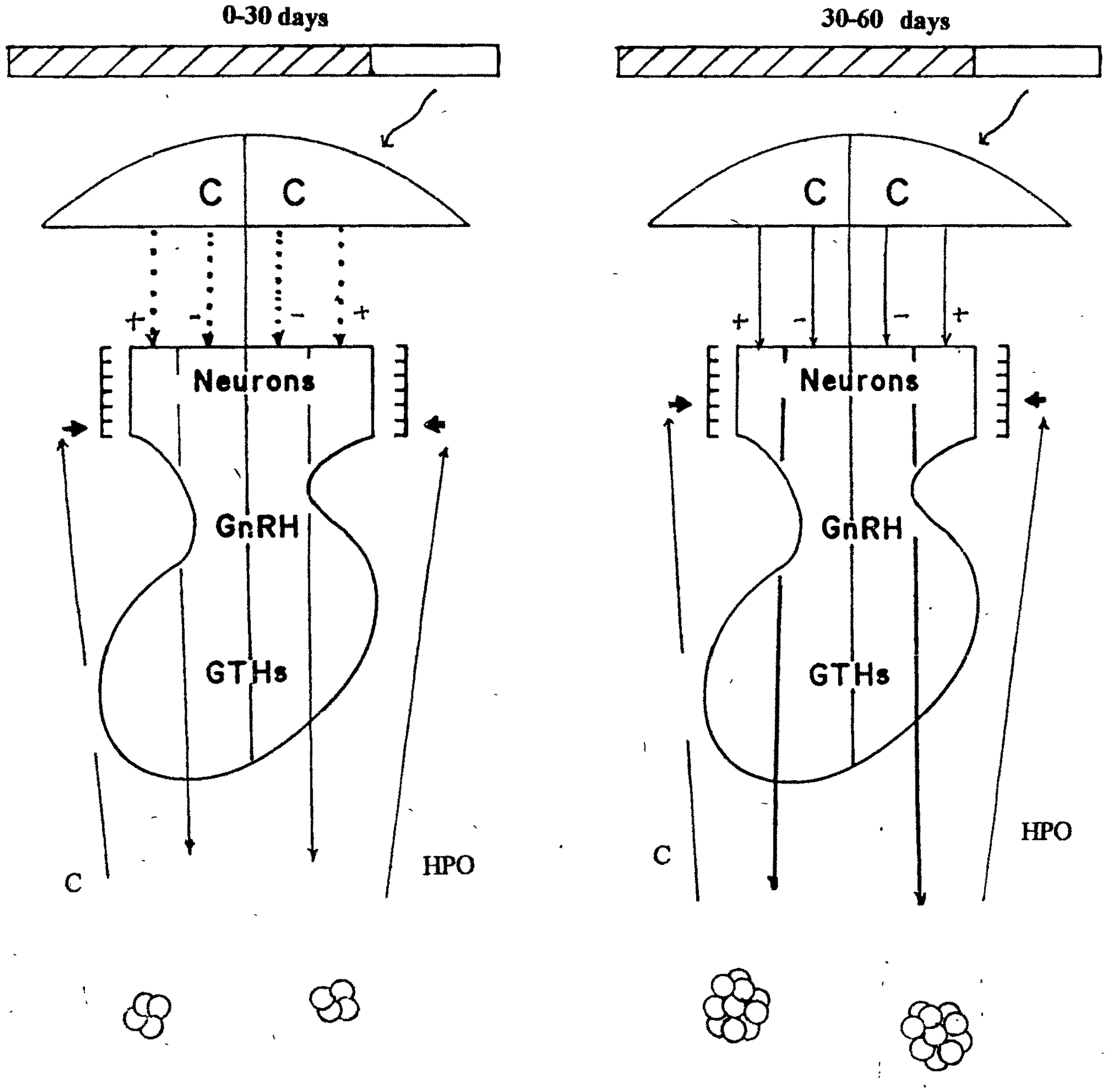
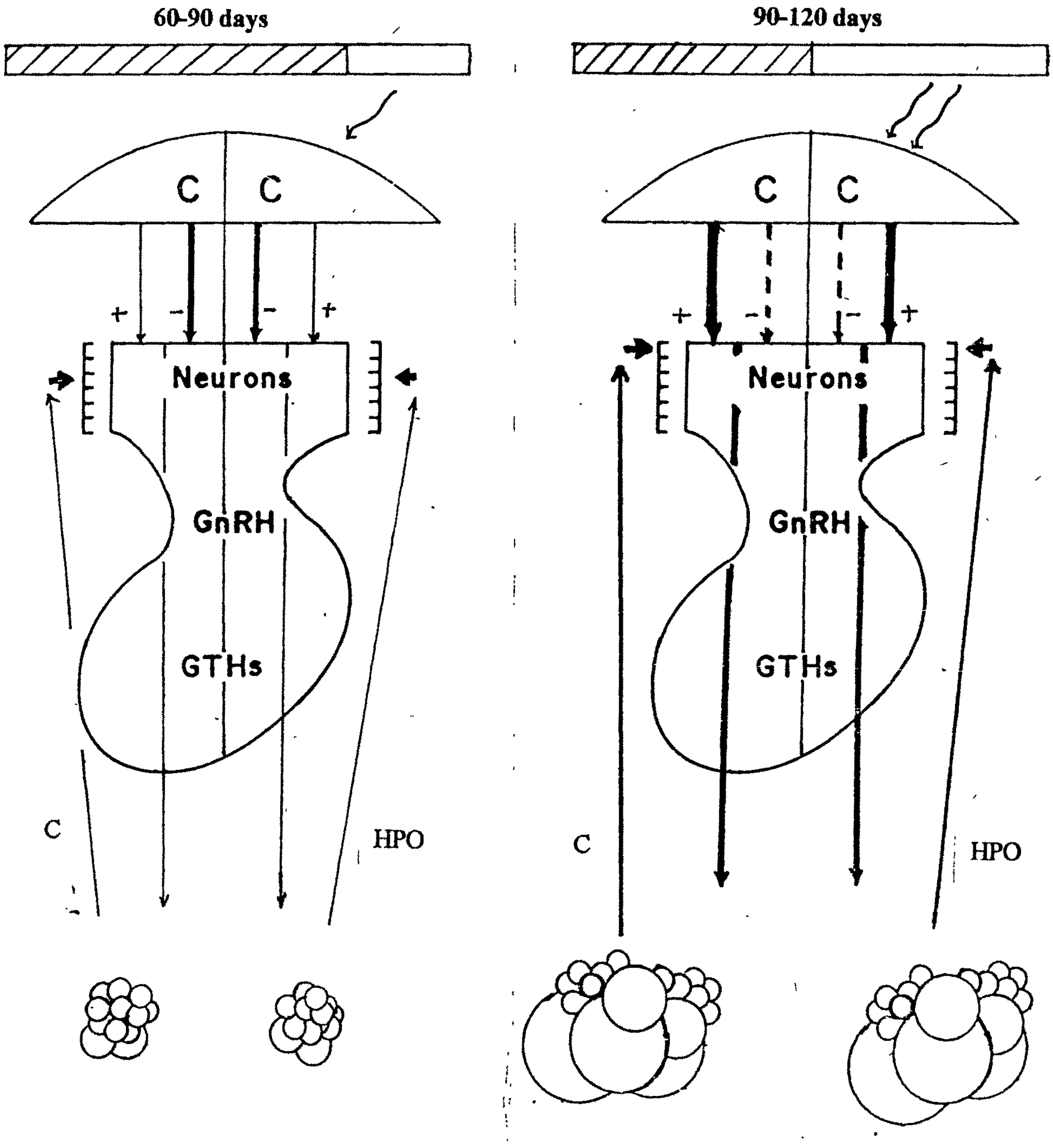

60-90 days
90-120 days
C
C
C
C
+
-
-
+
+
-
-
+
Neurons
Neurons
GnRH
GnRH
GTHs
GTHs
HPR
C
HPR

Diagram 6


0-30 days
30-60 days
C C
+ - - +
Neurons
GnRH
GTHs
C
HPO
C C
+ - - +
Neurons
GnRH
GTHs
C
HPO


60-90 days
90-120 days
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPO
C
C
+
-
-
+
Neurons
GnRH
GTHs
C
HPO

[Note 2. Either HPR or HPO has over riding / modulatory influence on the above events caused due to a step-up photoperiod.]

[Note 3. It is envisaged that local intraovarian regulatory mechanism are modulated more favourably under HPR and slightly unfavourably under HPO.]