

## GENERAL CONSIDERATIONS

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The Poultry birds are amongst 6000 known species of domesticated birds whose characteristic feature is its high rate of reproduction. In this era of modern scientific research, the field of poultry is at the fore front because of its obvious economic importance, It involves development of breeds of hens with the ability to ovulate large number of eggs, development of sophisticated feeding and management strategies and incubation technology. The development of artificial incubation technology has played a major role in this context and in the absence of which, poultry production would have to depend on a maternal cycle in which a hen lays about 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 eggs. the "brooding phase" which is a part of maternal behaviour in birds, can be delayed by frequent removal of eggs. This leads to decreased egg production which has been overcome in the case of white leghorn breed of hen, which is known for maintaining high egg-production. Isolation and selective breeding of genetically superior strains of poultry birds have led to the development of a parent stock capable of producing greater number of eggs and add to the table value as well. Gradually over the years, the poultry products (egg and meat) have gained importance and, constitutes one of the important parts of human diet. The egg remains an excellent source of nutrient and

is consumed at an annual rate of  $280 \times 10^9$  eggs the world over. Similarly, the poultry meat is consumed at a rate of 310 Kg/person in South Korea, Egypt, Sweden, Mexico and Switzerland, 10-20 Kg/person in New Zealand, Japan, Taiwan, South Africa, Europe, Venezuela, Brazil and Argentina, and 20-30 Kg/person in Australia, Saudi Arabia, Israel, Canada and USA. Hence the development of Broiler breed of chicken was an important step to fulfill the demand of chicken meat. Dual purpose breeds (for both egg and meat) were also developed and were major breeds of early part of 20th century. However, they still continue to be an important breed in most of the developing countries.

The post-independence era saw the development of poultry farming from a backyard venture to the present day modern poultry industry. The egg production was quite low till 1960 but, over the years, because of improved methods of rearing and development of vaccines against various diseases, the production increased appreciably. The Government of India in recognition, increased the allotment of funds to this sector in successive five year plans; Rs 28 million in the second plan (56-57 to 60-61) to Rs 602 million in the seventh plan (85-86 to 89-90). The value of poultry products went up from Rs 650 million in 1961 to Rs 10,000 million by the beginning of seventh five year plan and is expected to touch Rs 35,000 million by 2000 AD. India is now amongst the first top ten countries in terms of egg production. This was achieved by major progress in the fields of nutrition, genetic selection, disease control, management techniques and marketing. Still the egg production needs to be substantially increased by 8-10 folds to be at par with advanced countries. The per capita consumption of eggs in India which was 9.3/annum in 1971, 19.3/annum in 1981 and 22.5 in 1990, is expected to increase to about 30 / annum by 2000 AD. Though these figures are not bad, the development is not uniform. It is revealed

from the comparative data that except for states like Andhra Pradesh, Maharashtra, West Bengal, Tamil Nadu and Kerala, totally contributing to about 50% of the total egg production in the country, the contribution from other states is meagre. Same was the case of poultry meat industry, but with the emphasis on Broiler farming, the production has increased from 111,000 metric tonnes in 1979-81 to 240,000 metric tonnes in 1989 and, the broiler population has increased from hardly 4 million in 1971 to 150 million in 1990 (Panda, 1984; 1995). Also, a preferential increase in consumption of poultry meat has been observed from 13.1% to 15.15% to total meat production from 1986 to 1994 (Panda, 1986; 1995). However, the per capita availability of meat is much less as compared to the developed countries and needs to be substantially increased.

Several factors, such as breed, genetic aspects and environmental variables (nutrition, disease control and management practices) have to be carefully manipulated to raise poultry production to the maximum possible potential. The recent scientific advances in the field of vaccination, genetics and nutrition and the new innovative ideas in the poultry management technology are quite substantial, but the use of environmental factors like temperature and light to maximize the genetic potential has not been fully explored or given adequate attention in India. The effect of environmental lighting and temperature on the neuroendocrine system of poultry birds has been studied in considerable detail in western countries. These studies have led to increment in egg yield and hence photoperiodic manipulations, even today, remains the most powerful management tool in poultry industry. It has been known to affect varied aspects of reproduction like age of onset of lay (AFE), rate of lay, the timing of lay, shell quality, egg size and feed efficiency. A photic schedules comprises of three possible ways of commercial application.

1. Conventional lighting regimen - with a single photophase (period of illumination) and single scotophase (period of darkness) totalling 24 hrs.
2. Intermittent, split or skeleton lighting regimen - with more than one photophase and scotophase 24 hrs. with symmetric or asymmetric intervals.
3. Ahemeral lighting regimen - with recurring periods of light and darkness that in combination may be larger or shorter but not equal to 24 hrs. in length.

The effect of photoperiodic manipulations maximum during the immature stages and hence, various lighting schedules have been attempted successfully to increase poultry productivity in the western countries. The lighting regime employed in India from the day of hatch, is based on a schedule borrowed from the western management practice. There has always been a need felt to evaluate the effects of different photic schedules on Indian breeds or under Indian conditions (tropical) as the response to photic manipulation is likely to be altered in relation to genetic status of the breed as well as climatic conditions. The effect of light : dark schedule on poultry productivity is essentially via modulating neuroendocrine mechanisms. Similarly, direct hormonal manipulations are also capable of influencing sexual maturity and egg yield. But such experiments have never been attempted. Hence, the present study aims at assessing possible effects of rearing pullets from the day of hatch till 90 days under a long photic schedule LD 18:6 (LP) and then shifting them to normal photoperiod of LD 12:12 (NLD) which together qualifies as a step-down photic schedule. Further, it was thought pertinent to assess the effect of mild hypercorticalism (HPR.) or hypocorticalism (HPO.) during the rearing stage (day 1 to 90). These studies have been extended further by

evaluating the combined effect on photoperiodic and adrenocortical manipulation to garner information of 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 long to short (step-down photic schedule; LP), the freshly hatched pullets were exposed to a long photoperiod of LD 18:6 from day 1 to day 90 and then transferred to a normal photoperiod of LD 12:12. The LP birds showed a delayed initiation in egg laying. This delay of 28 days in Indian RIR breed compares similar to the delay seen in ISA Brown and Shaver 288 breeds by 22 and 16 days respectively; when the photoperiod was reduced by 5 hrs (from 13 to 8 hrs) at 84 days or 119 days respectively (Lewis, *et al.*, 1996 b). This effect was photoperiod specific as the quantum of feed allotted was the same in both the groups of birds (NLD and LP). The overall egg output of LP birds was less by 8% as compared to NLD birds, but due to the shortened period of lay, the per day per hen yield and the between egg interval were both better by 7%. Also, LP birds laid lesser number of small eggs (<40 gms) and showed an overall positive response in rate of lay which is in quite contrast to the negative response shown by ISA Brown and Shaver 288 breeds (Lewis *et al.*, 1996 b). The present study also recorded no significant difference in the body weights of NLD and LP hens though there was a marginal increment in the latter. These results are indicative of no possible correlation between body weight and reproductive maturity, though photoperiod has a definite influence on the physiology of the reproductive system, as temporally regulated optimised photoperiodic changes can influence the laying performance of domestic hens. Similarly conclusions have been drawn in the Indian RIR under step-up photoperiod (Dandekar, 1998) and temperate species of domestic hens (Lewis *et al.*,

1996 a,b,c). There was no significant difference in terms of feed consumption per dozen eggs in NLD and LP hens (3.65 Kg. Vs 3.75 Kg.). However, the allocated diet provided in the present study was at an average 2.8% less than the feed consumption at the Government poultry farm (*ad libitum* schedule) (see chapter 2, table 8) yet did not show any adverse effects on egg production. A step down photoperiodic manipulation at the fag end of first cycle of lay proved to be under productive as the LP hens laid 17.7% lesser eggs than NLD hens with an overall poorer rate of lay. Overall, a step-down photoperiod at the interphase between brooding and growing periods (58-60 days) has no significant effect on the overall egg laying performance but has a significant favourable influence on the rate of lay.

The manipulation involving adrenocortical status, involving induction of mild HPR or HPO in pullets from day 1 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 a 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 laying at an average 15% more eggs and, the HPO hens laying 22% lower eggs. The average egg weight was also higher in the HPR in 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 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 long photoperiod has revealed significant modulatory interactions of both photoperiod and adrenocortical status on the laying performance of the RIR hens. Both, HPR and HPO seem to have a significant obviating effect on LP induced delay in initiation of egg laying as the former condition advanced egg laying by 13 days and the latter condition by 76 days. The HPR birds showed a significantly longer period of lay ( by 56 days) as a

result of early initiation (by 13 days) and delayed termination (by 43 days). The HPO hens showed a early initiation but also an early termination which reduced the effective period of lay (by 18 days). In terms of total number of eggs, LP+HPR showed an overall 16% improved egg lay over LP which is in accordance with the observed additive influence of HPR over SP (Dandekar, 1998). However, HPR hens showed a poor rate of lay, nullifying the favourable effect of LP, while the HPO hens showed an improved rate of lay representing a cumulative effect of HPR and LP. The feed consumed per dozen eggs is an indication of the rate of lay which is predictably much better in HPO. When considered in terms of cost analysis on a large flock of birds as in a poultry farm, HPO seems to have a definite favourable influence on the overall poultry economy. In terms of second cycle of lay, superimposition of either HPR or HPO on LP has a cumulative depressive effect on the second cycle of lay suggesting differential interactions between adrenocortical status and photoperiod in adult hens with consequent effects on second cycle of lay.

An avian egg constitutes of macro and micronutrients which provides nourishment for the developing embryo and hence is considered an ideal component of human diet. It is considered as an excellent source of protein and vitamins with also adequate quantities of lipids and minor amount of carbohydrate. In this respect, the chemical composition of egg is of greater relevance and it shows considerable variation depending on the type of breed, management practice, composition of feed etc. The metabolic rates of liver, ovary and oviduct play a key role in synthesis and deposition of these micronutrients. Since the various photoperiodic schedules or hormonal manipulations are known to have an impact on egg laying, it may further have effects on the composition of eggs as well via neuroendocrine modulations. Hence, the present study aims at assessing

changes in physical features and chemical composition in the eggs of birds subjected to photoperiodic and/or adrenocortical manipulation.

The eggs of LP birds showed increased protein and cholesterol content in yolk and albumen as compared to NLD birds. The total lipid content showed an increment in yolk and decrement in albumen of eggs of LP birds, suggesting alterations in the metabolism of liver and oviduct. A comparison of the calorific value of NLD and LP eggs shows higher energy content in the eggs of LP birds (in terms of per 100 gm edible egg). Overall, these results suggest a positive effect of LP on egg composition, a hitherto unreported evidence.

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 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 vitellogenesis. 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. Even the eggs of HPO hens were 14% more

than the control hens. 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.

Transient chronic mild HPR or HPO in the rearing stages have certain subtle influence on metabolic features in the adult condition in relation to reproductive functions. The effect of the same has been observed in egg laying cycle of hens subjected to mild hyper. or hypocorticalism and reared under a normal or step-down photic schedule from day 1 to day 90 during pullet stage, and thereafter, maintained under NLD schedule (see chapter 3, 4). Effect of short photoperiod and HPR or HPO on egg composition has been reported (Dandekar, 1998). In the present study, the HPR condition along with LP has no influence on the protein and lipid fractions indicating that, unlike LP or HPR alone, a combination of the two has an overall nullifying effect. But the albumen cholesterol content increased proportionately in eggs of HPR birds, suggesting a qualitative and quantitative alteration in the lipoprotein metabolism of the oviduct. Also, LP+HPR tends to nullify the independent positive effects of both, as there was no net change in the calorific value of eggs. The eggs of HPO birds showed increased protein, lipid and cholesterol contents in albumen suggesting an obviating influence of HPO on LP induced decrement as reported earlier (chapter 5). These results indicate some specific effects on the metabolite load of the eggs, and that, corticosteroid-photoperiod interactions in the growing phases have potential effects on the biochemical composition of the eggs by subtly altering the metabolic homeostasis of liver and oviduct.

These experimental manipulations involving a step-down photoperiod and/or HPR or HPO in the growing phase has subtle differential effects on the growth rates and growth kinetics of thyroid, adrenal, ovary, oviduct, liver and lymphoid organs (thymus, bursa and spleen). 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. There seems to be a complex interaction of various hormones with an altered homeostatic balance and sensitivity, as the levels of corticosterone and thyroid hormones were not strictly correlatable with the growth rate and growth indices of various organs. Hence, there is a need to evaluate possible subtle neuroendocrine interactions, altered sensitivities of hormones and their synergistic and antagonistic influences in this experimental set up to have a better understanding of differential manifestations.

Sharp (1993) has suggested a hypothetical scheme on the influences of photoperiods on the hypothalamo-hypophyseal axis as related to ovarian growth and functions. Based on the observations in various species of birds including domestic hen, it was suggested that, an increase in photoperiod sends stimulatory inputs to the GnRH neurons, whereas, decrease in photoperiod nullifies the stimulatory input and sends an inhibitory input which dissipates gradually after several weeks or months of exposure to short days. The histological and histometric data of the ovary, in the present experimental schedule, reflects the characteristic influences of experimental manipulations on the hypothalamo-hypophyseal ovarian axis.

The above results indicate certain subtle influences of this experimental schedule on the ovarian follicular growth and maturation in pullets stage, and further, it has definite effects on their egg laying cycle and egg composition. A hypothesis of the underlying mechanism is explained diagrammatically (see diags. 1 to 6).

#### **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 action of gonadotropin.

#### **Diagrams 4:**

*Schematic representation hypothesizing the influence of LP on the HHG axis in pullets.*

The schema hypothesizes augmented positive input to the GnRH neurons from the controlling centre under LP. Continued exposure to LP sets in photorefractoriness by 90 days. Thereby dissipating the positive input which persists for 30 days after shift to normal photoperiod primarily. This results in equally strong positive and negative inputs at 120 and days and slows down ovarian growth. This is followed by gradual increase in the

**LEGENDS FOR DIAGRAMS 1 TO 6**

**CC** - controlling centre (hypothalamus)

**GnRH** - Gonadotropin releasing hormone

**GTH** - Gonadotropic hormone

→ set-point



Gradation of intensity of +ve and -ve inputs from the controlling centres to

GnRH neuróns in response to photoperiod.

Output / feed back

.....→ very weak

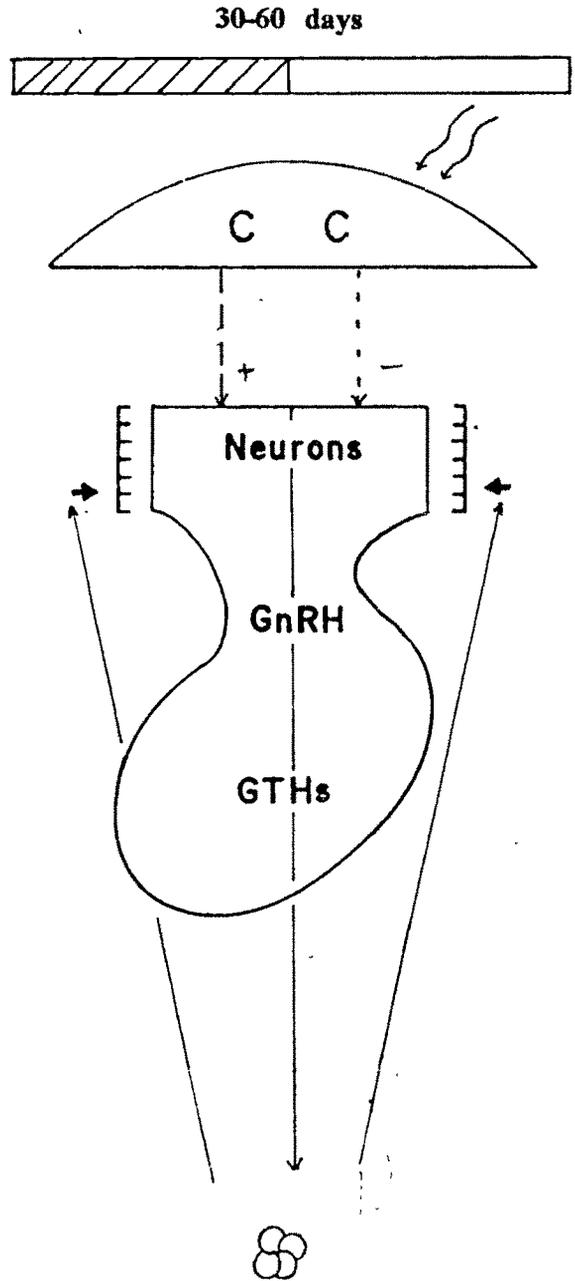
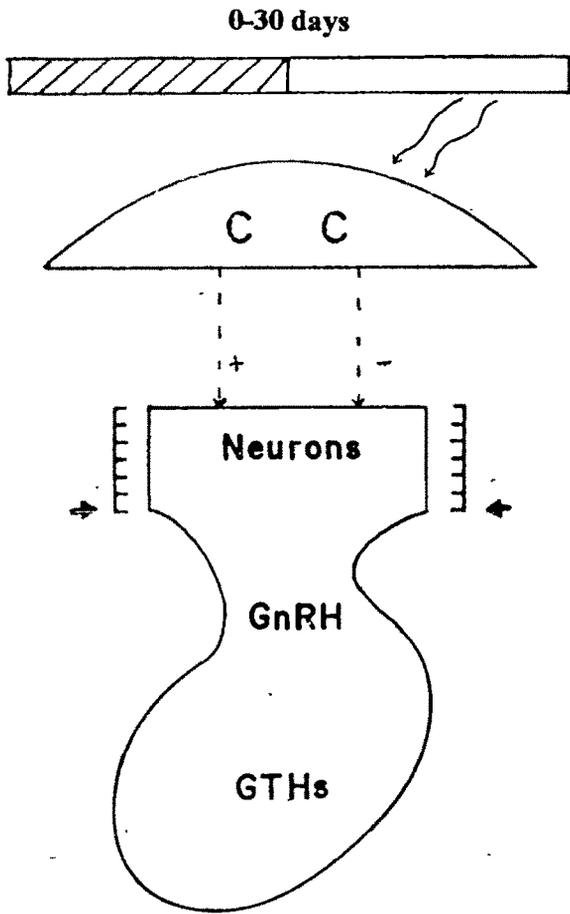
---→ weak

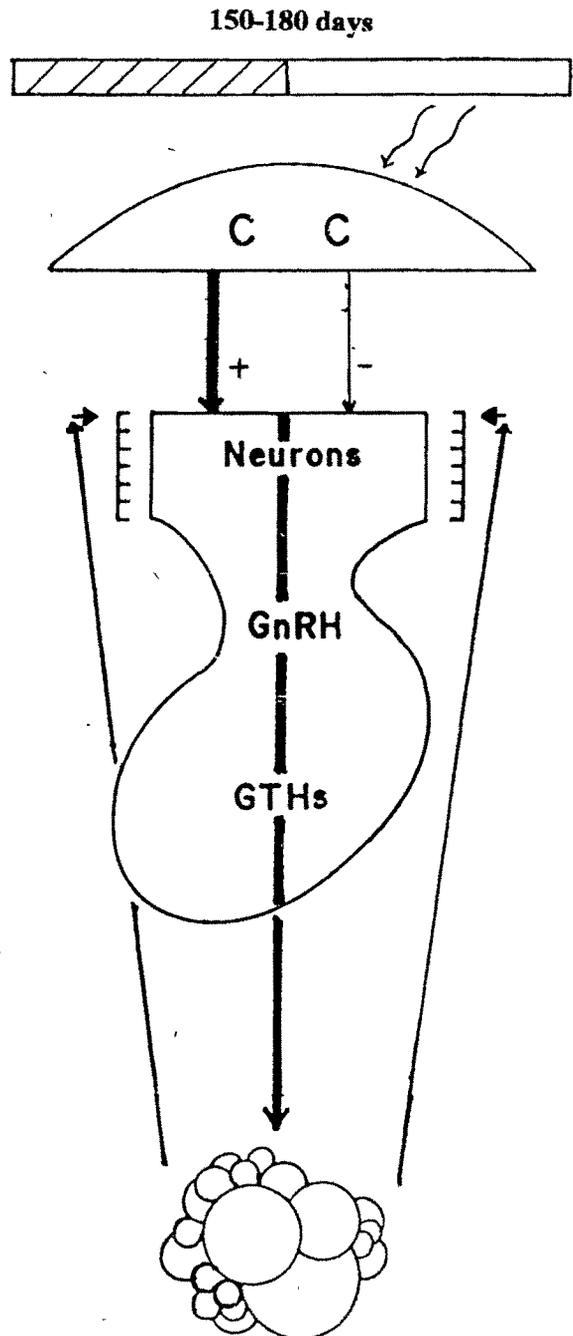
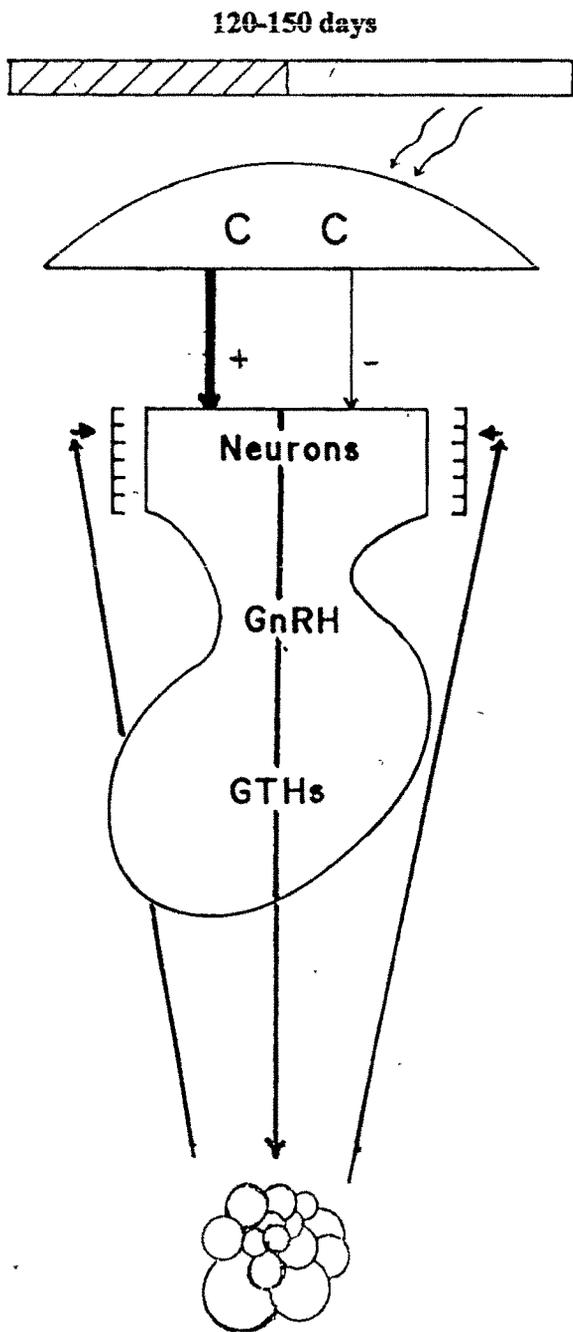
→ mild

→ strong

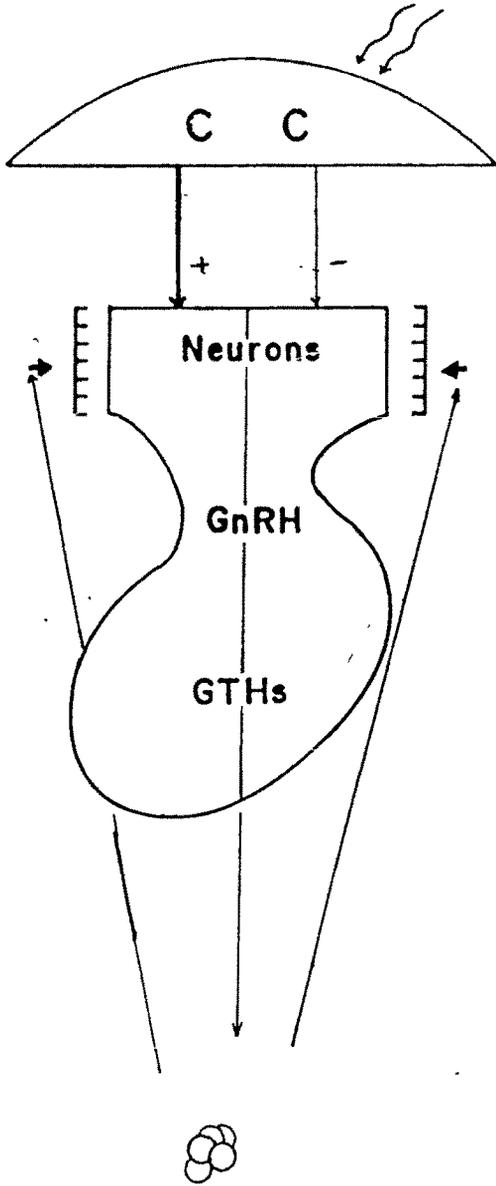
→ very strong

Diagram 1





60-90 days



90-120 days

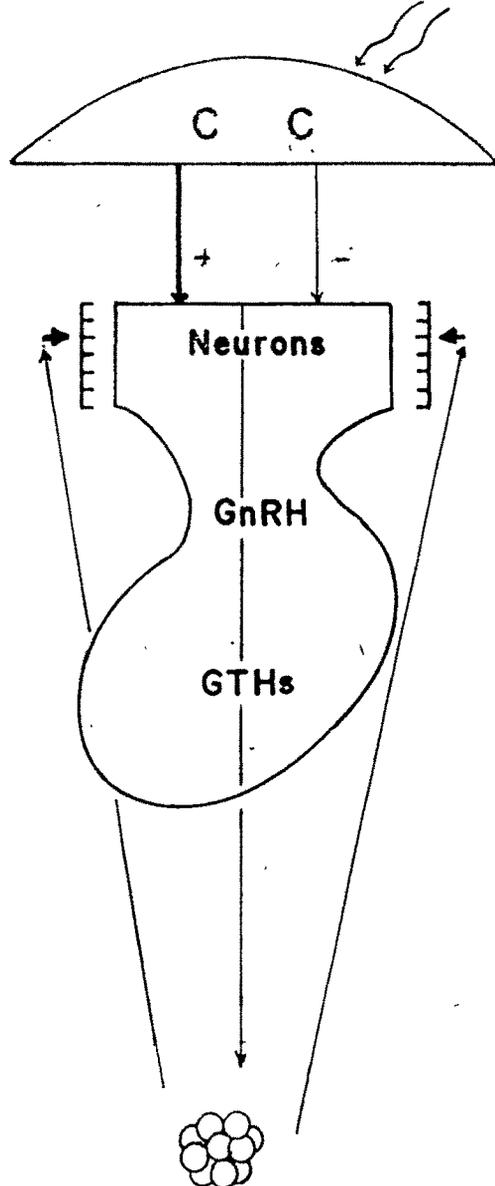
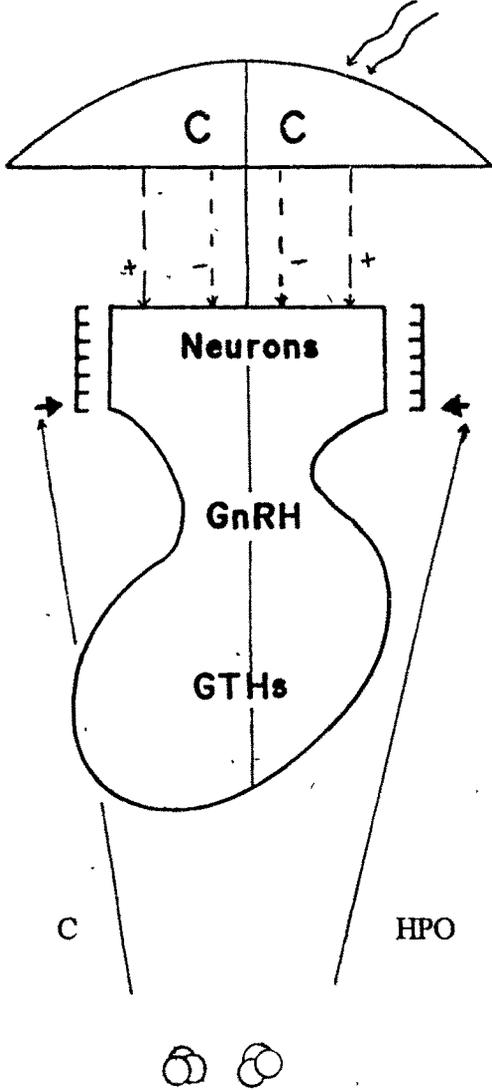
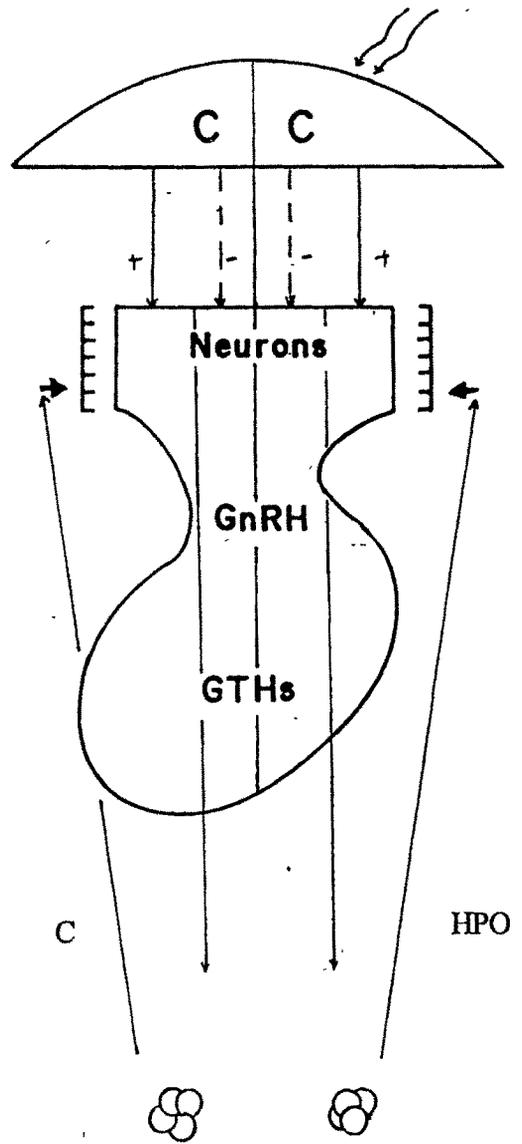
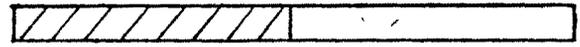


Diagram 2

0-30 days

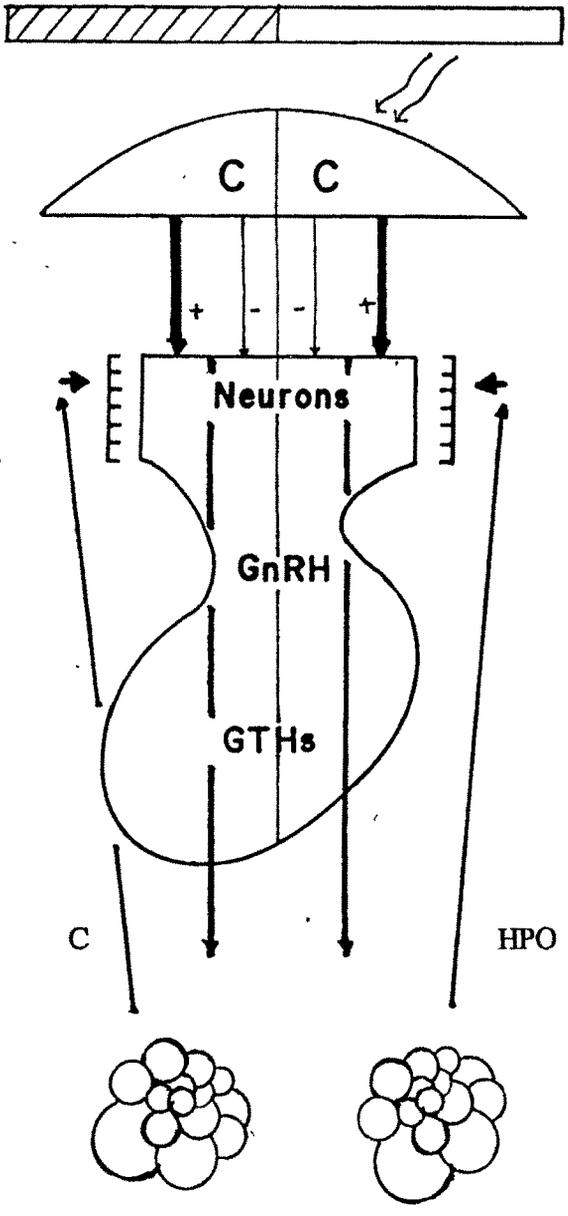


30-60 days





120-150 days



150-180 days

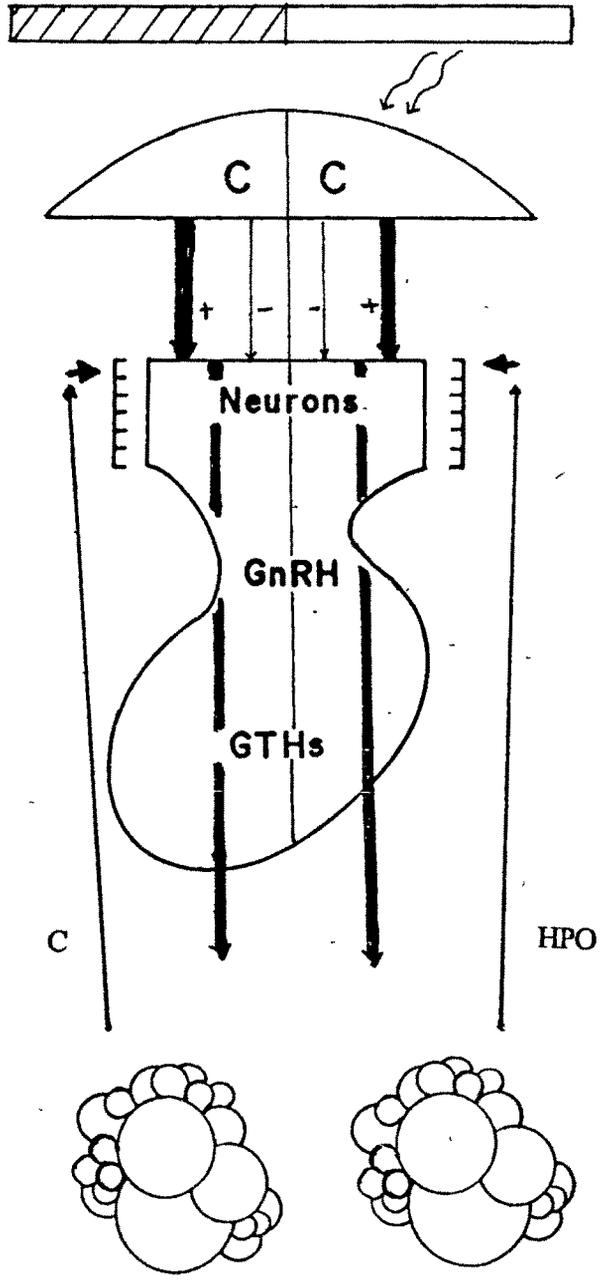
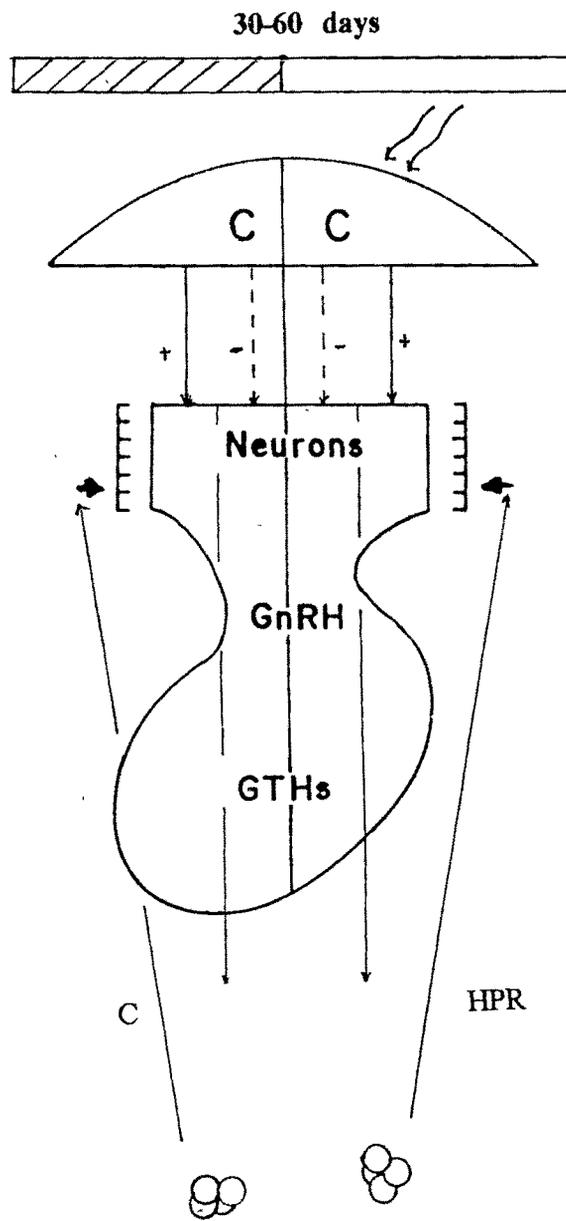
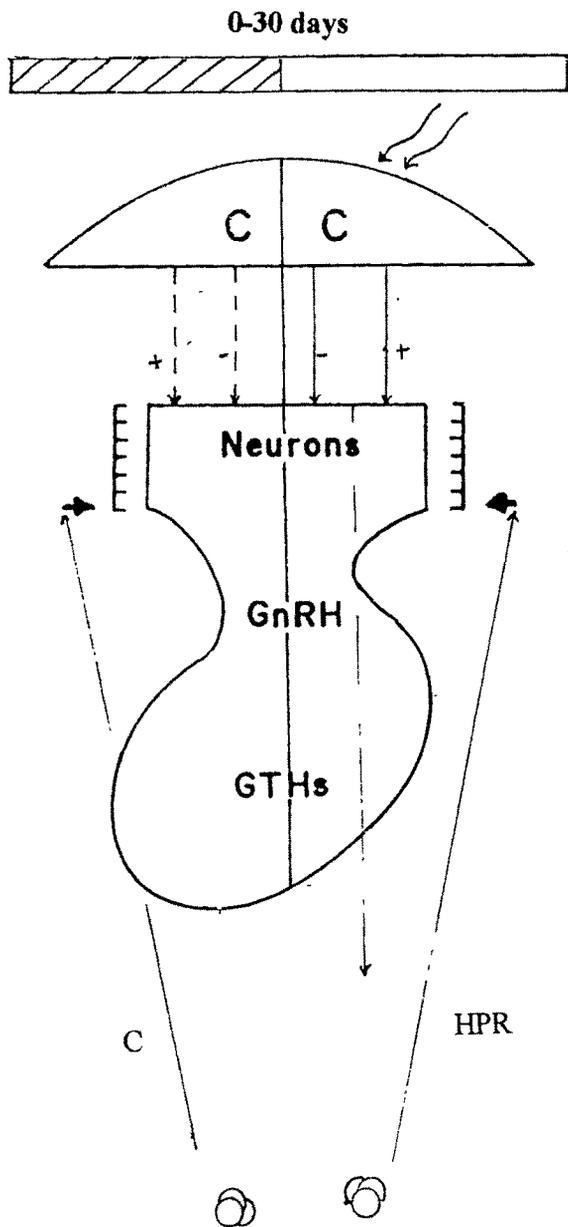
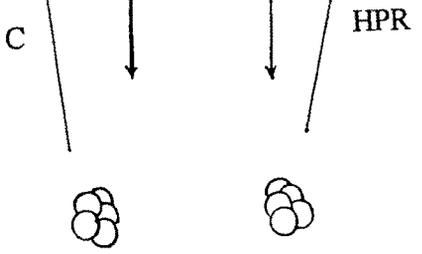
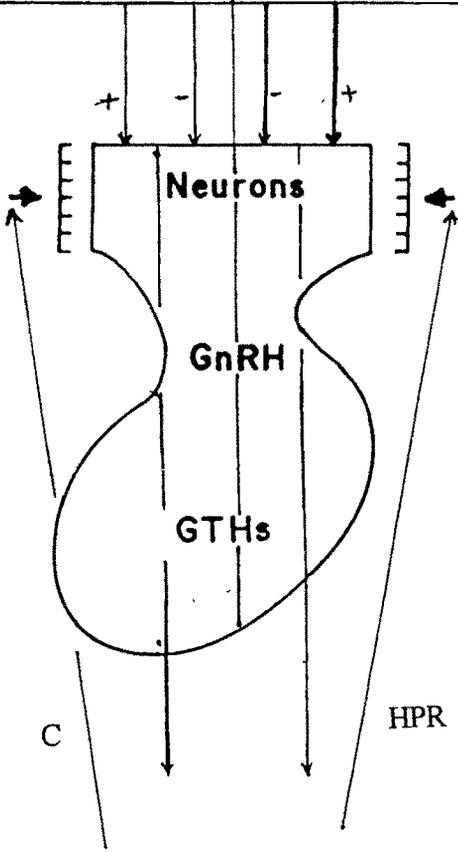
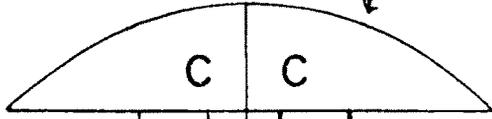
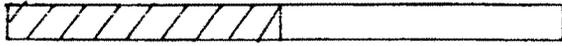


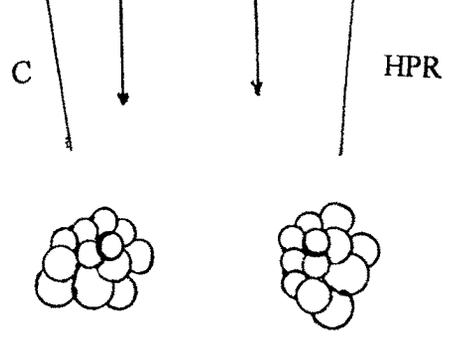
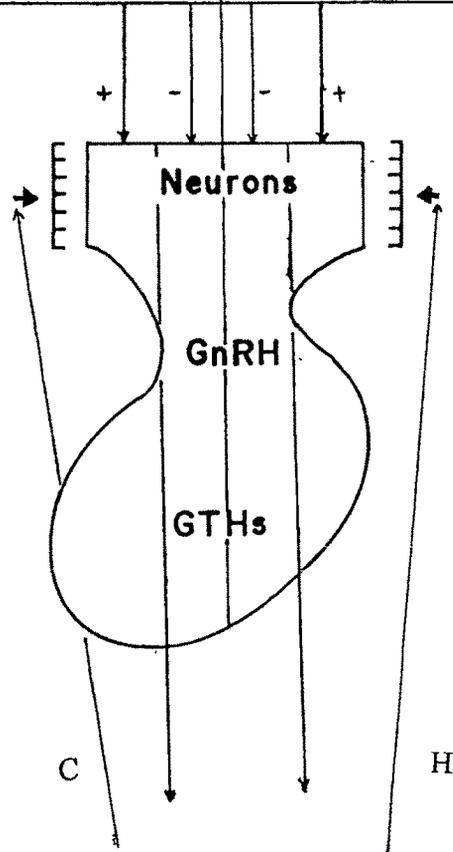
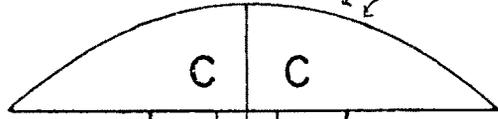
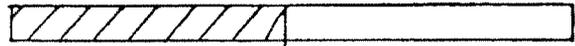
Diagram 3



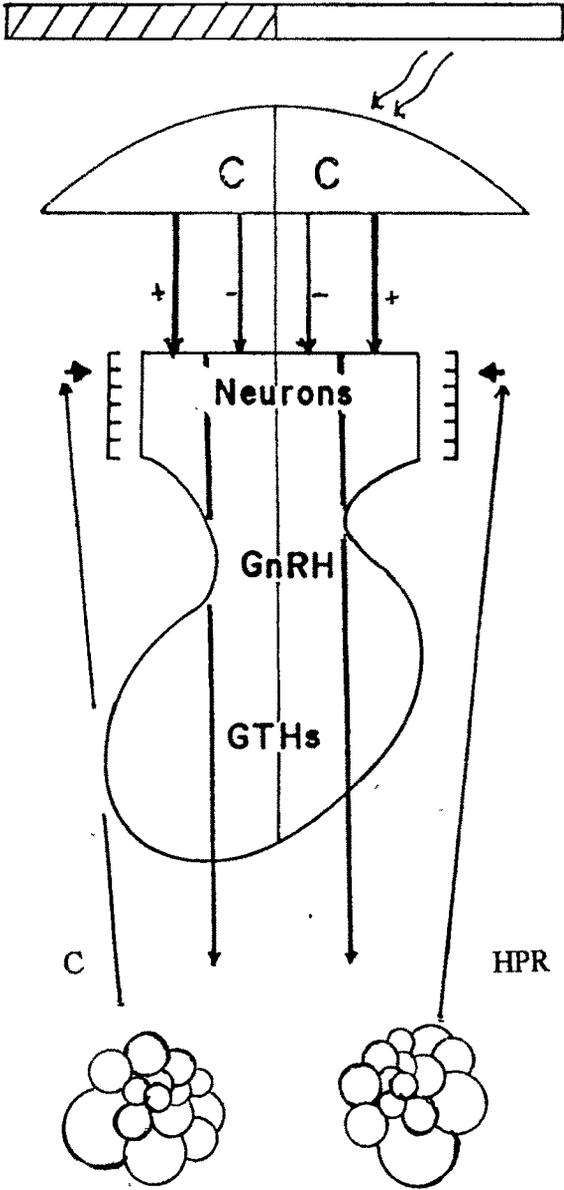
60-90 days



90-120 days



120-150 days



150-180 days

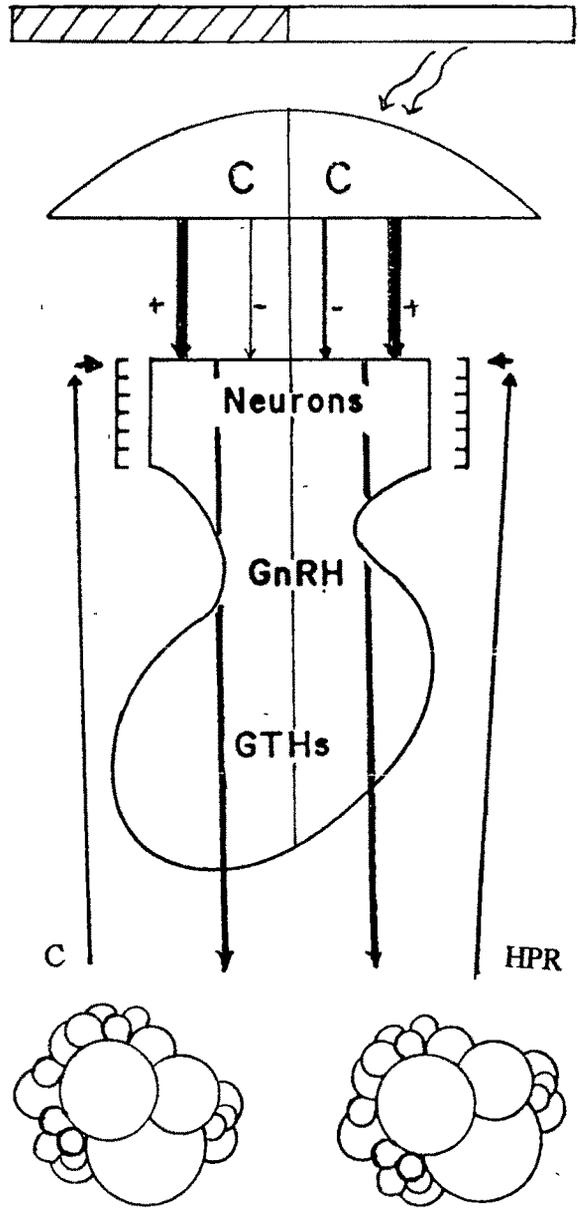
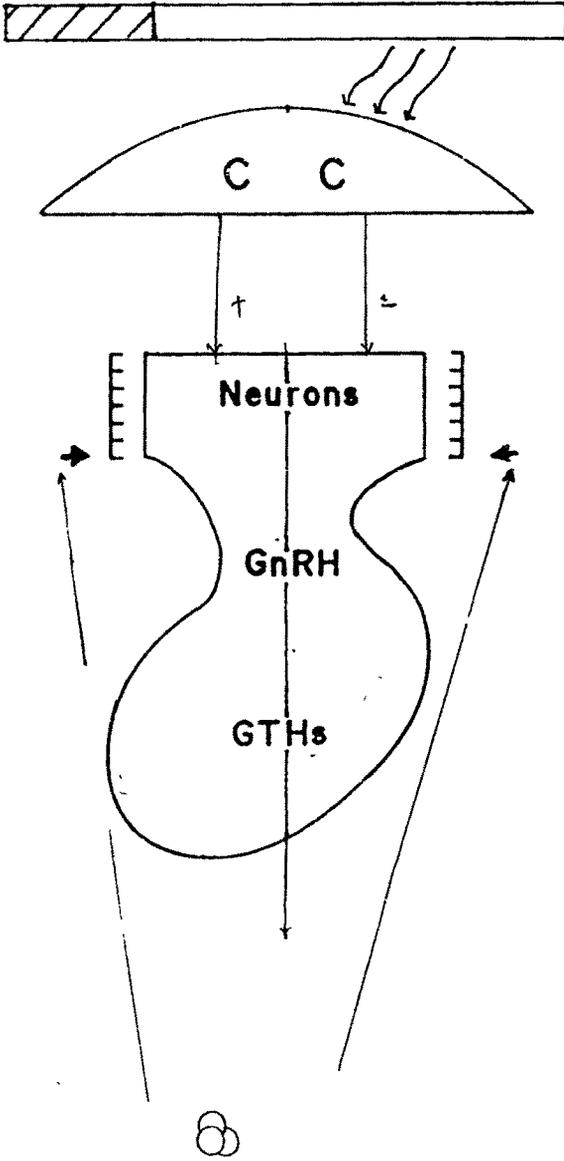
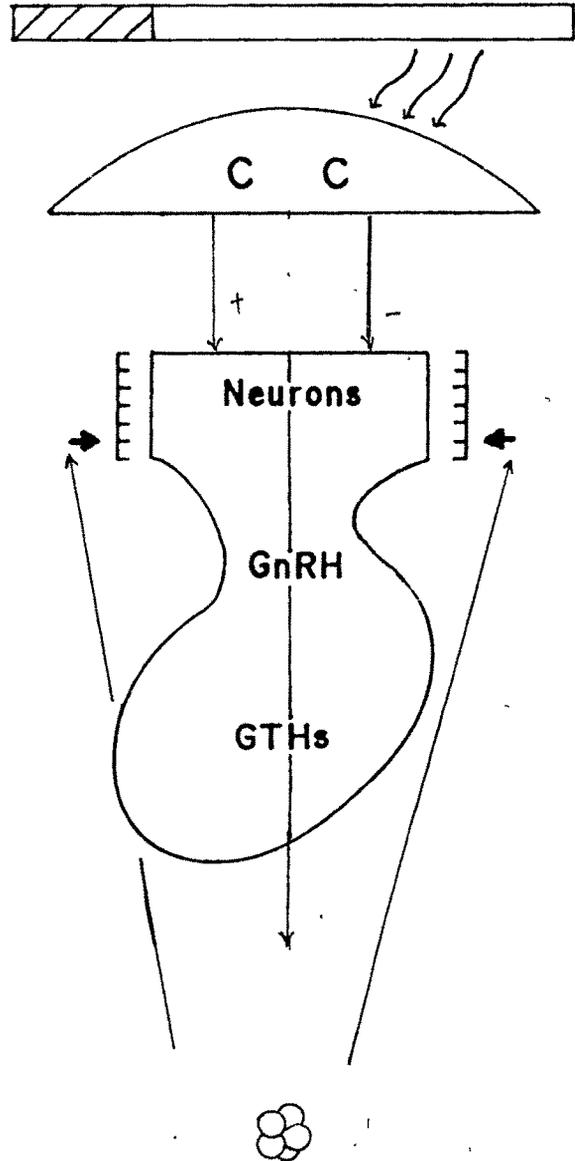


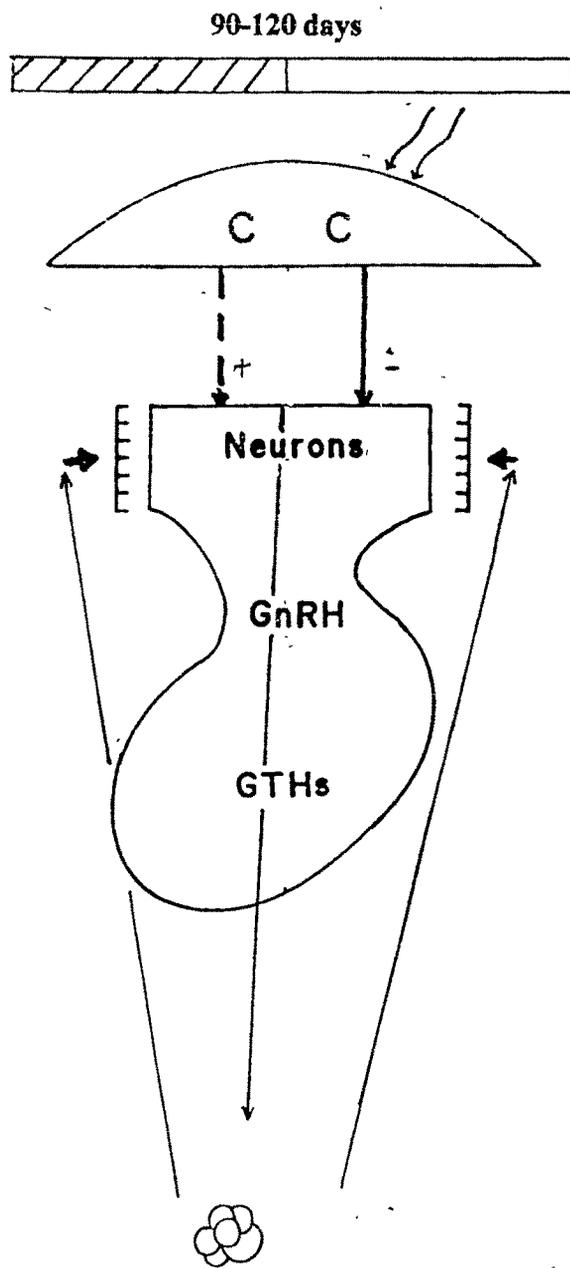
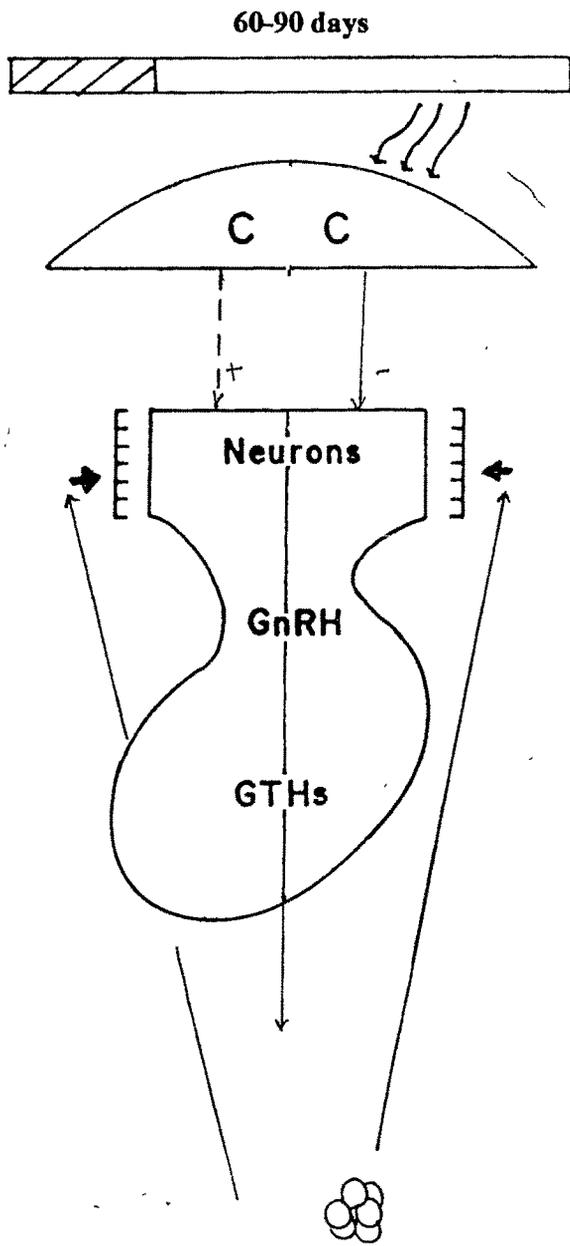
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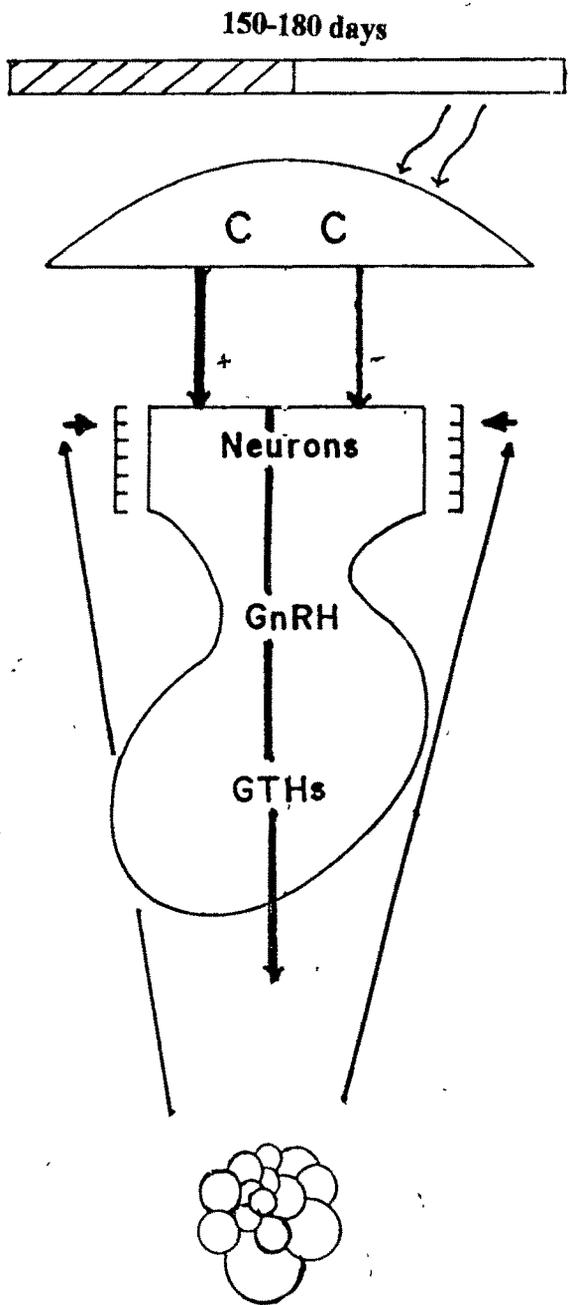
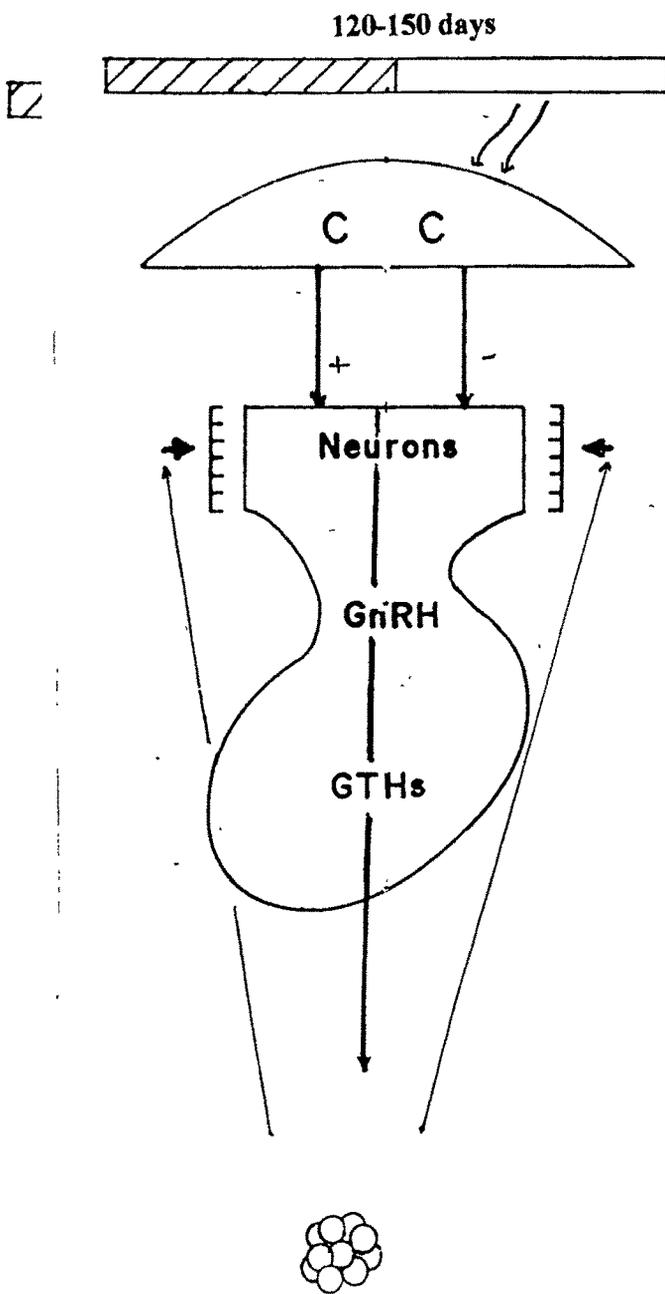
0-30 days



30-60 days







180-210 days

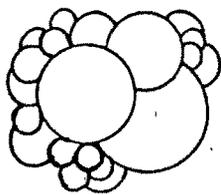
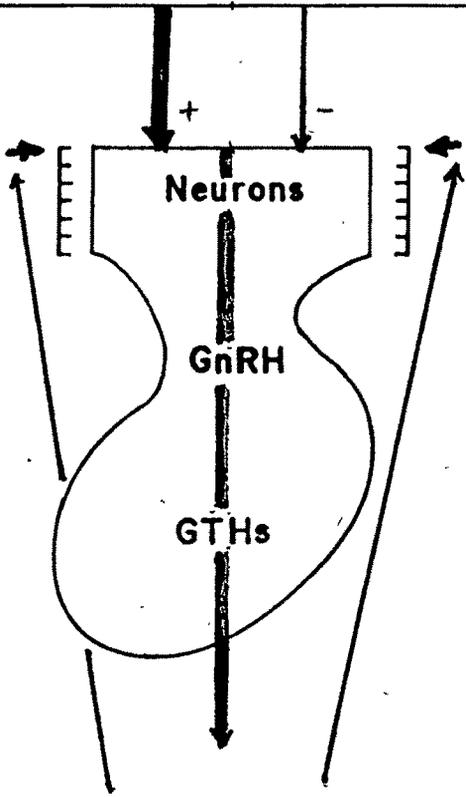
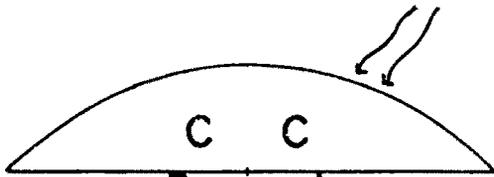
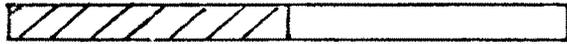
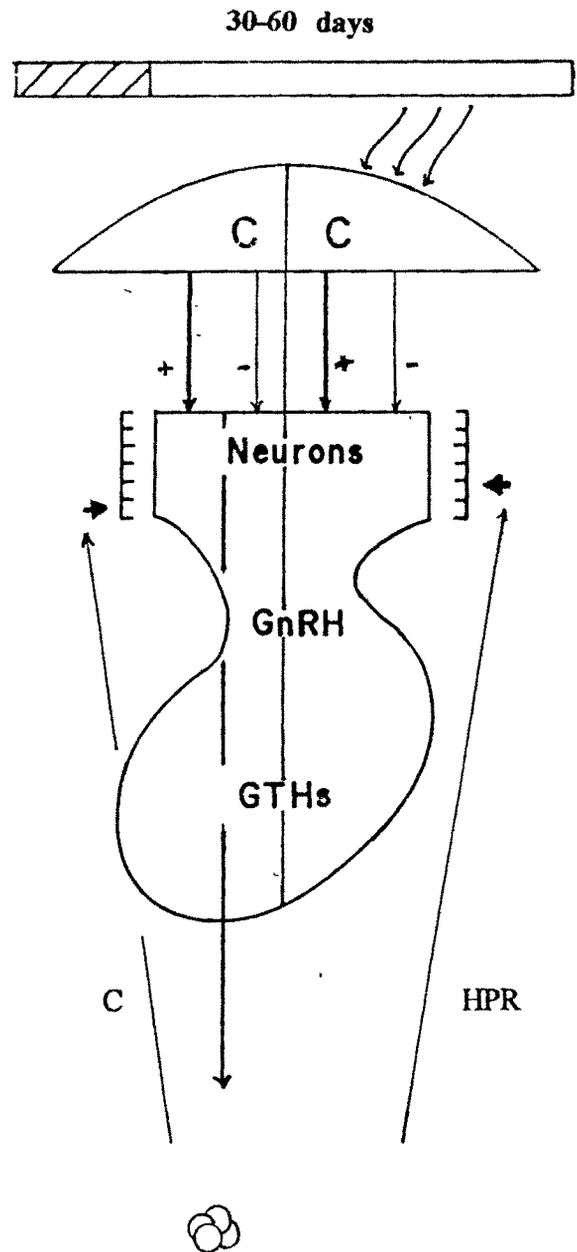
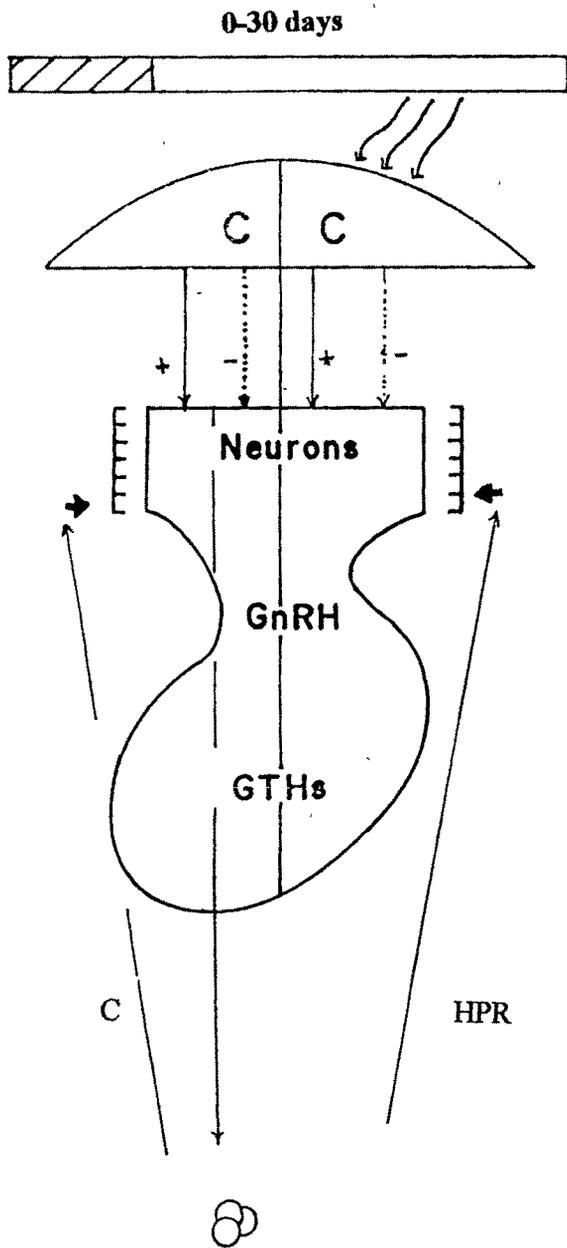
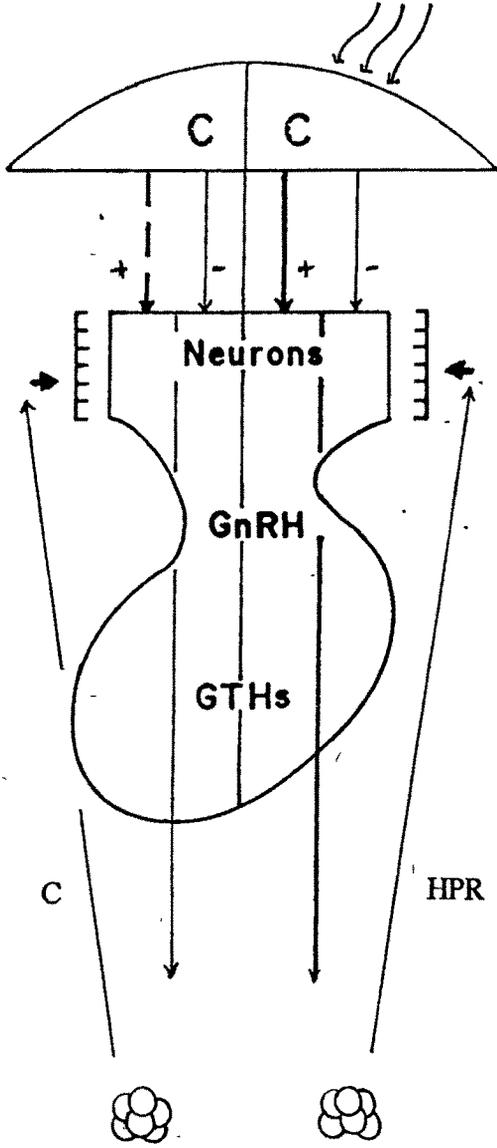
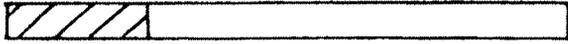


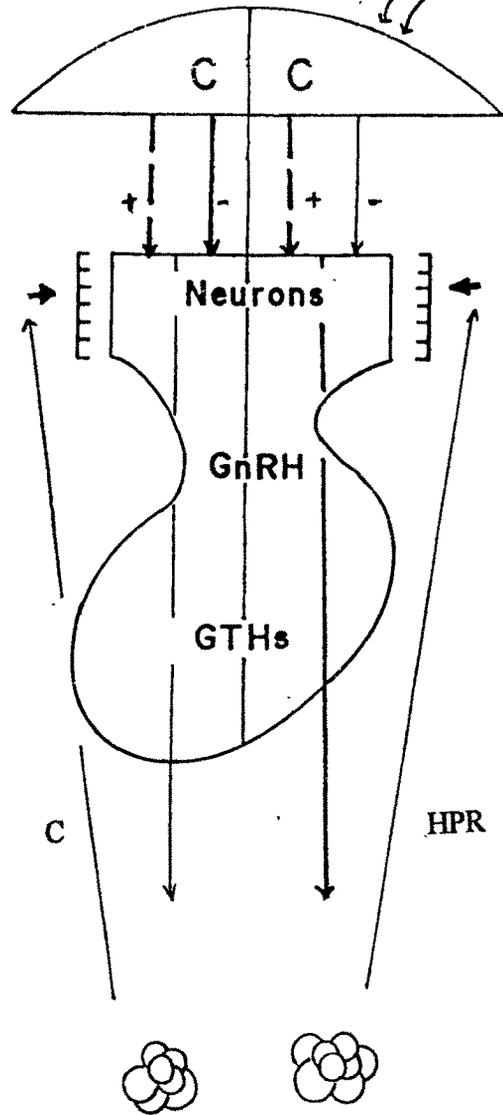
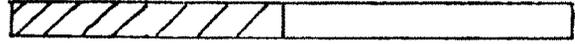
Diagram 5

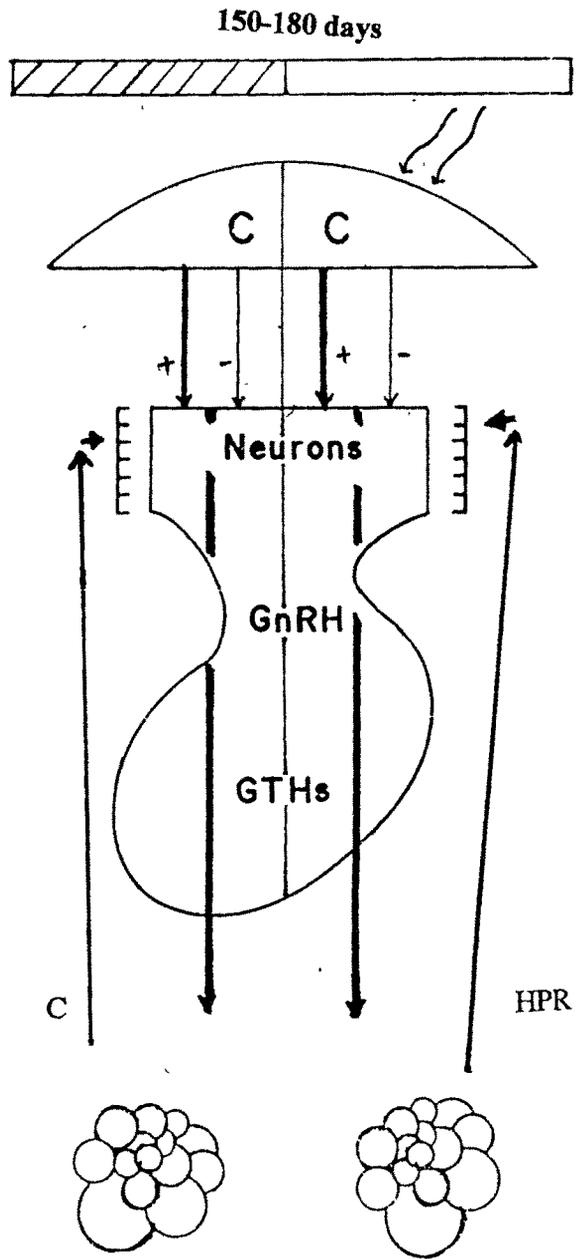
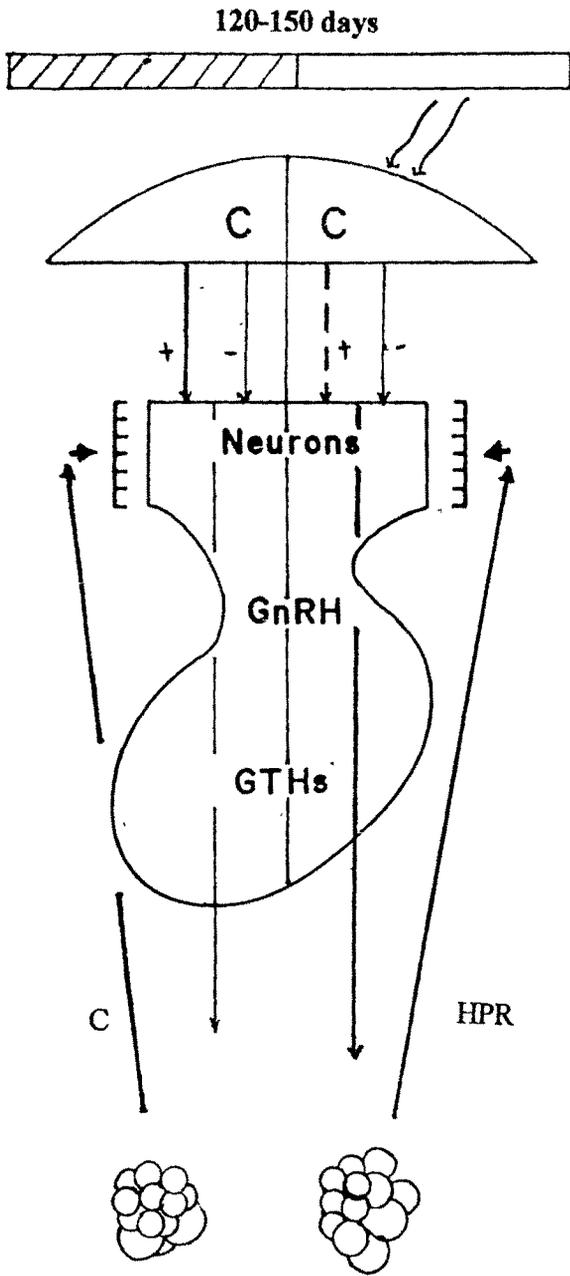


60-90 days



90-120 days





180-210 days

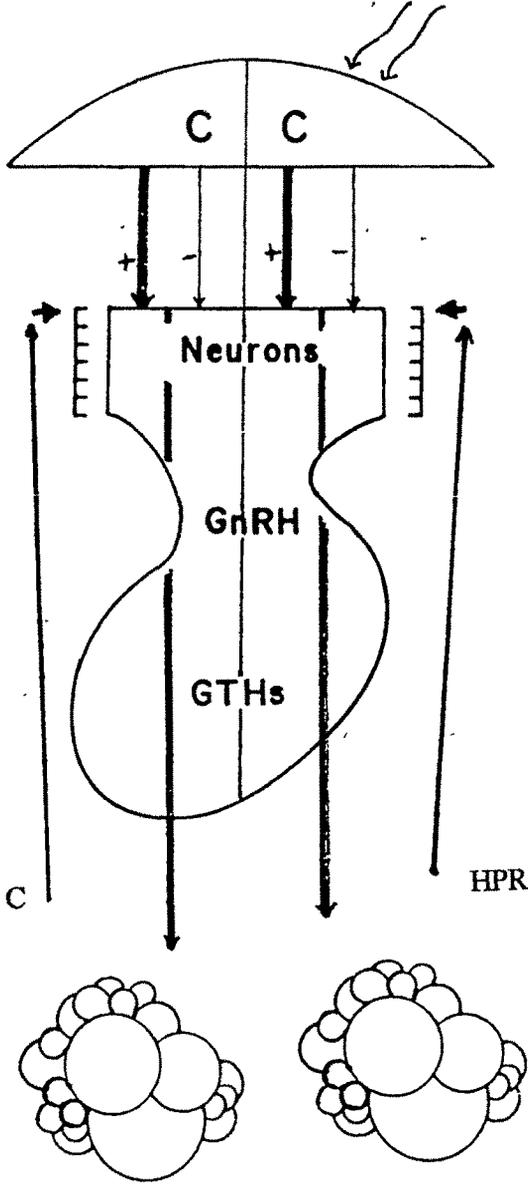
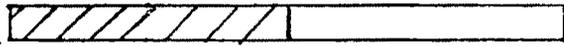
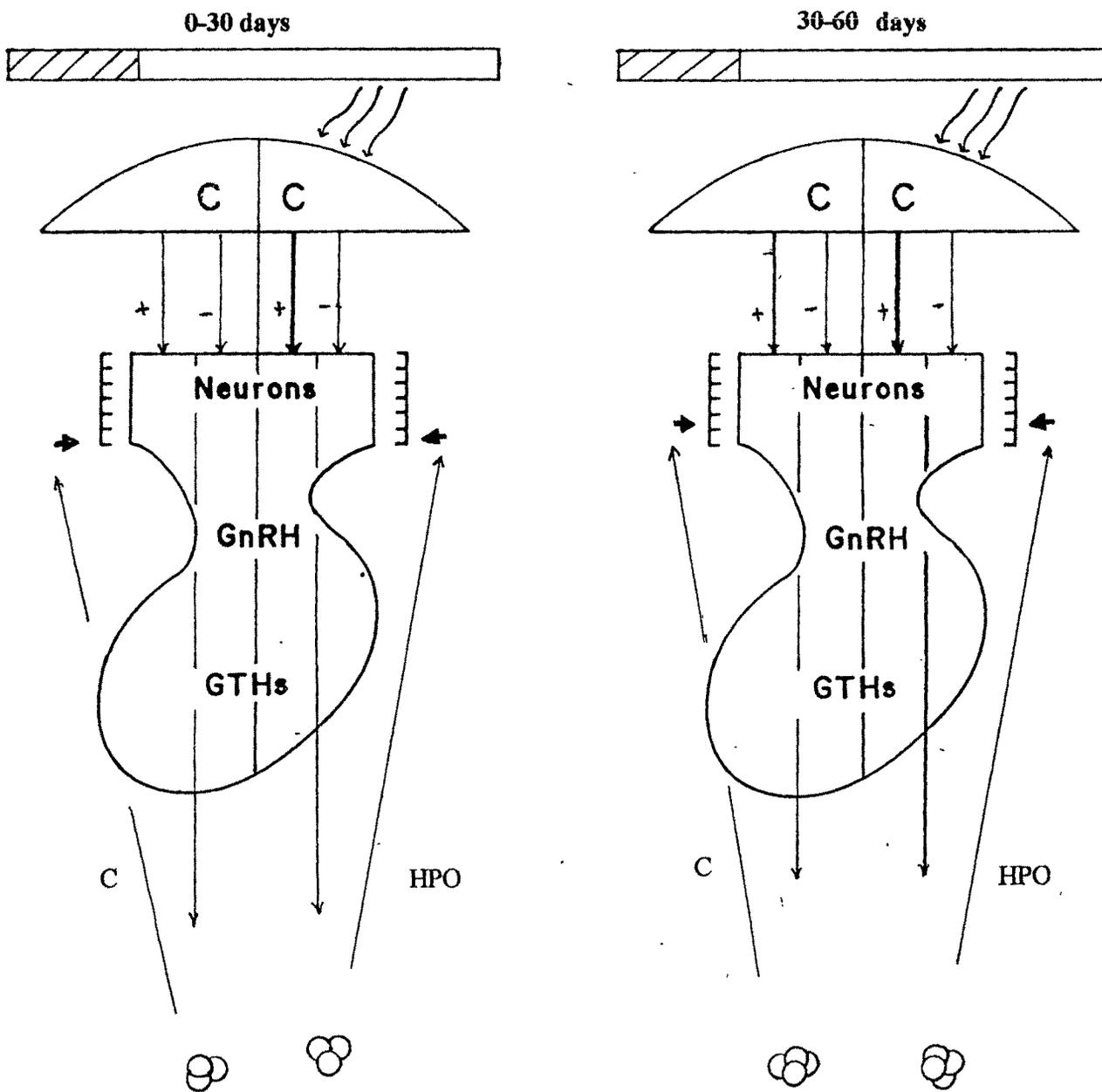
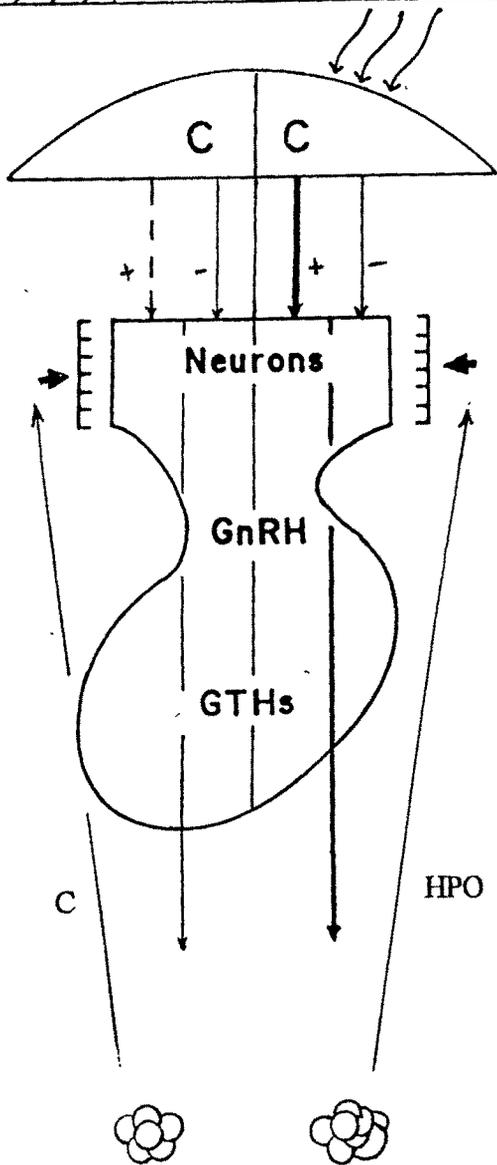
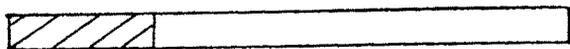


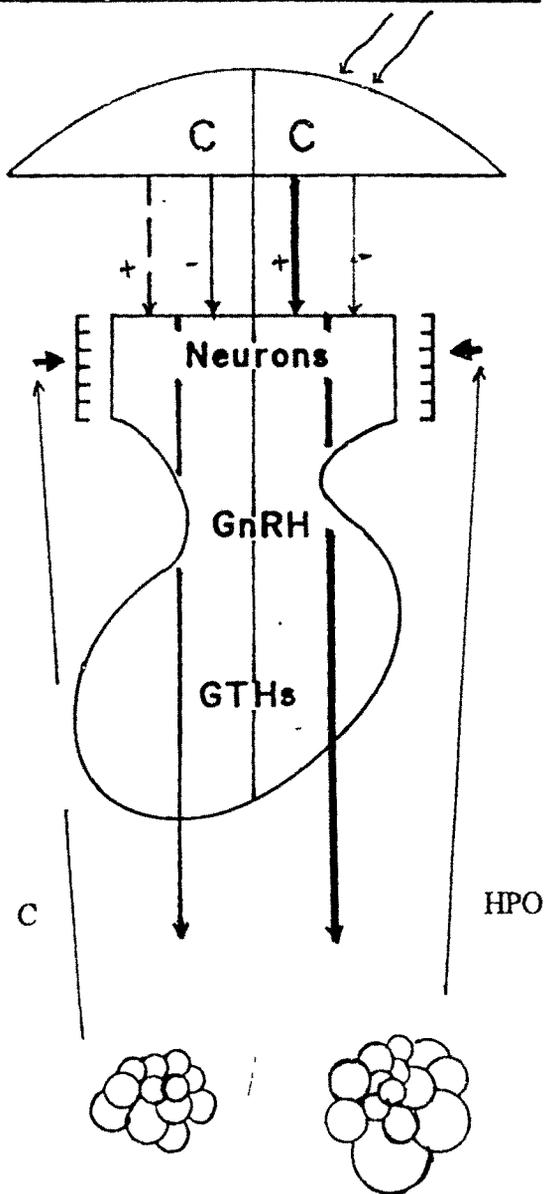
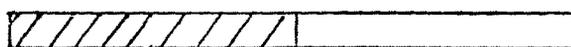
Diagram 6



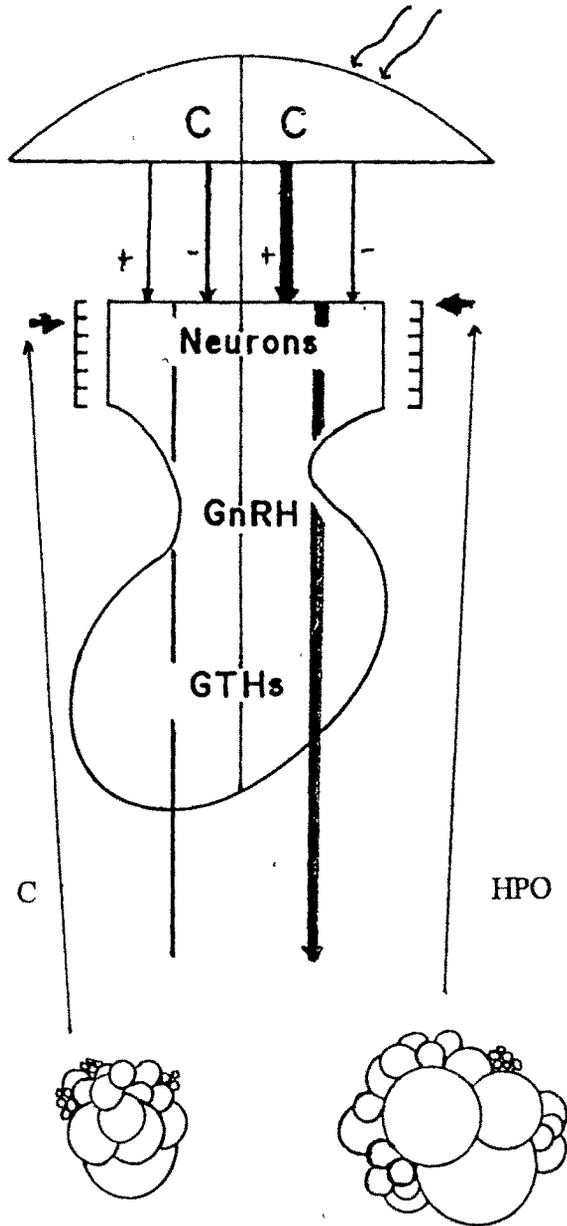
60-90 days



90-120 days



120-150 days



positive input under NLD and attainment of the maximal exposure to the HH axis from 120-180 days. It is also purported that the hypothalamic set-point for negative feedback action of gonadal steroids is raised under LP resulting in greater HH output up to 60 days of exposure to LP.

**Diagram 5:**

*Schematic representation hypothesizing the influence of HPR under LP on the HHG axis in pullets.*

The schema purports that the photorefractoriness is delayed and is of a lesser magnitude under HPR. The hypothalamic set-point for the negative feedback of the gonadal steroids also seems to be raised higher during exposure to LP during initial phases, than with LP alone. Therefore HPR seems to have more potential effects of gonadotropic hormones on ovary under HPR.

**Diagram 6:**

*Schematic representation hypothesizing the influence of HPO under LP on the HHG axis in pullets.*

The schema hypothesizes that the LP induced photorefractoriness is totally blocked by HPO thereby favouring continued activation of the HH axis. The hypothalamic set-point of the negative feedback action of gonadal steroids is also raised higher related to LP at all stages. Overall there is faster ovarian growth and early egg laying.