I. INTRODUCTION
The metabolism of poikilothermal animals, as measured by the oxygen consumption, is a highly complex physiological process subject to the influence of a number of factors, intrinsic as well as extrinsic, such as body size, nutritional state, sex, age etc. and temperature, salinity, pH, oxygen tension etc. of the medium. All these factors, collectively and individually, influence the metabolism of the animal.

Body size:

It is well known that one of the most important of the intrinsic factors influencing the metabolism of an animal is its own body size and that metabolism varies directly with the body size. This has been rightly emphasized by many workers (Edwards and Irving, 1943 a, 1943 b; Weymouth, Crissou, Hall, Belding and Field 1944; Zeuthen, 1947, 1953, 1955; Pampanathla Rao, 1953; Toshien, 1956; Vernberg, 1956, 1959; Roberts, 1957 a; Parvatheswararao, 1959, 1960; Saroja, 1959). The available literature on this topic has been thoroughly reviewed by Hemmingsen (1934), Kleiber (1947) and Zeuthen (1947, 1953). It has been shown that oxygen consumption varied in relation to body surface in annelids (Kragger, 1952; Saroja, 1959) in crustacea (Weymouth et al., 1944; Ellenby, 1951a; Scholander, Plagge, Walter and Irving, 1943; Zeuthen, 1953; Bertel, 1949).

This relationship holds true in several other groups of animals and therefore the size of the animal is an important factor which should be considered in metabolic studies.
female upae of *Drosophila* (Lindby and vans, 1936), fishes (Smith, 1935; Scholander et al., 1953; Parvatheswararao, 1953) and other forms, it has been shown that oxygen consumption varied in proportion to body weight. In several fishes an intermediate condition between surface area dependence and weight dependence has been reported (Zeuthen, 1971; Scholander et al., 1953; Job, 1955; Parvatheswararao, 1959). It has been pointed out that in a great majority of cases studied amongst fishes, the increase in the oxygen consumption with size is surface area dependent rather than weight dependent (Fishop, 1950; Fry, 1957). Bertainanffy (1951) distinguished three metabolic types amongst animals, surface area dependent with a value of 0.66, weight dependent with a value of 1.0 and intermediate type with a value of about 0.8. But Zeuthen (1953, 1955) stresses that the exponent $n$ is not such a simple value and it is highly variable under varying physiological conditions (as shown by Illiasen in *Artemia salina*, 1952) and at different stages of ontogeny (Clark, 1957) in the same species, in closely related species and also in the phylogenetically related groups. Consequently there must be many more metabolic types than the three suggested by Bertainanffy (1951). Most often $n$ never exceeds 1, except in rare cases, where it is due to the operation of a complexity of factors other than size (Zeuthen, 1953, 1955; Brody, 1945; Pampapathi Rao, 1958 b). It is also known that either extremely low or extremely high $n$ values result out
Inconsistency in the Solution of Inconsistency

Selection of numerical results in the form of "b-value.

The work of Vernberg (1932) on two species of earthworms illustrated this fact. The body length depends on the state of acclimation of the species (in red and irving, 1933 by larsen the black, 147; sarasota, 1960; sarasota, 1963). X-ray crystallography, the bit of body weight decreases with increasing size. The patterns of a heterochromatin are described by larsen (147) in brodi (146). However, trichoplusia ni a general rule. It is a matter of great biological significance that not all species are increasing size. A case to be easier in northern forms than in the southern ones. This affords to the northern forms to grow to bigger sizes than the southern ones (pamorath, 1953).

Starvation.

Starvation is known to affect oxygen consumption and there are comparatively few studies in this regard (wells, 1935; smith, 1935 a; dewes, 1930; pantel, 1939; phillips and brockway, 1954; mann, 1956; roberts, 1957 a; vernberg, 1959 b; rajabali, 1961; ramamurthy, 1961). In all these cases it has been clearly demonstrated that starvation decreases the level of oxygen consumption except in the case of the locust (aphidiphora conspersana) where at least in the
The first seven days of effects of starvation in fishes may be due to the feeding habit of the fish, which is capable of storing blood or ions. In a host of studies different patterns of the relation of oxygen consumption, consequent upon starvation, have been reported. In the crab, *Echinopsylla crassipes* (Roberts, 1957 a), ling fish *Pteropterus lethiopinus* (Smith, 1935 a) and a few others, the decr ease has been consistent, with a sharp rise in *Pteropterus lethiopinus* before death. In the crab *Uca* (Vernberg, 1959 a) the attainment of a steady level after an initial increase in oxygen consumption has been reported. At least so far as fishes are concerned there appears to be adaptation to starvation through the lowering of metabolic level (Cantelow, 1955). Evidence is at hand that several of the physiological and ecological variables influence the effects of starvation. Accordingly in fishes, *Pleuronectes* (Rawes, 1939) and *Salvelinus fontinalis* (Adelman, Bingham and Waith, 1955) it has been shown that smaller fish are more susceptible to the effects of starvation and more so at higher temperatures. Wells (1950), studying the effects of starvation on the oxygen consumption of *Oreilia nigricans*, suggested that more active fish show effects of starvation more quickly than the less active ones. Vernberg (1959 a) reports in the crab, *Uca pugnax* that starvation affects thermal acclimatization. When subjected to starvation, the tendency to acclimate apparent in the first.
feeding maintained the pattern of acclimation for at least 21 days. This aspect (viz., starvation) is of particular interest in the recent studies since the fish were not found to feed normally under conditions of thermal acclimation (high as well as low temperature).

Temperature:

Amongst the several biotic factors, perhaps, temperature is the most important, influencing the metabolism of pink lothers (Delehanty, 1933, 1935; Vell, 1935 a; Edwards, 1946; Zeuthen, 1947; Pampapathi Rao, 1953; Pampapathi Rao and Tullcock, 1954; Precht, Christophersen and Hensel, 1955; Jon, 1955; Fashian, 1956; Johnson, 1957; Roberts, 1957 a, b; Vembi, 1959 and others). As a general rule with temperature increasing the metabolic rate increases and with temperature decreasing the metabolic rate decreases, provided the kinetic zone is adhered to in the course of the measurements. A most important requisite in the measurement of the temperature effect on the metabolic rate is the selection of proper temperature ranges. If the change is too steep, metabolism may be depressed or the animal may even die (Christophersen and Precht, 1952). There is a good lot of documented evidence to indicate that the metabolic response to temperature changes is dependent upon the size of the animal and its recent thermal history (Fen, 1936, 1938, 1939; Fox and Wingfield, 1937; Schelander et al., 1953; Pampapathi Rao, 1953; Pampapathi Rao and Nutlich, 1954; Roberts, 1957 and others.)
Many cases it has been shown that size dependence of metabolic rate is minimal at low temperatures but as temperature increases the size dependence steadily increases. This is shown to be true not only in single populations but also in different populations from colder and warmer regions (Fells, 1935 a; Zeutner, 1947; Karpatichi, et al., 1953, Parvatheswararao, 1953, 1960; Saroja, 1959).

The fact that most fishes are independent of oxygen concentration in water down to 1 c.c. or even less per liter has been established by several investigators (inter alia, Amberson 1938; Henze, 1910; Saarder, 1918; Mayerson and Scott, 1924; Toriyu, 1927; Crozier and Stier, 1925 and others). This finding minimizes, if not completely eliminates, the possibility of errors arising out of varying oxygen tensions in the measurement of metabolic rates at different temperature levels. Hence in the present studies the relation between O₂ tension and O₂ consumption was not investigated. However, every effort was made to see that the O₂ tension of the water, in which measurements were made, was sufficiently high at all times.

The desirability of taking size into consideration in the studies on temperature-metabolism relations has been emphasized by several workers not only due to its proportionate influence on the physiological processes at a given temperature but also due to its influence on the pattern of development depending on changes in temperature in the ontogeny.
Consequently, the evidence presented in the recent studies, such as that of Dr. Smith (1935a, 1935b, 1935c), indicates their being highly significant from the point of view of their bringing to light metabolic differences between populations from different thermal regimes, rather than absolute validity on the basis of lack of consideration of the size factor.

The increasing steepness of the Arrhenius curve in the case of smaller fishes at higher temperatures is interpreted by Wells (1935a) as due to greater activity of smaller fishes at higher temperatures. Small fishes could not see any difference in the locomotor activity between smaller and larger fish at higher temperatures. Hence he makes an alternative suggestion that larger fish exercise economy in expending energy or doing the same amount of work. This appears purely hypothetical. It is more likely that the temperature sensitivity of smaller fish is physiologically different from that of larger fish. Bishop (1950) is of the view that the metabolism of smaller oikotherms responds to temperature changes much more markedly than does that of larger ones. But this interpretation is erroneously based on the absolute response of metabolism to temperature changes rather than proportionate response. Belehradek (1930, 1935) states that physiological activities, most often, show increasing temperature sensitivity with age. We would rather criticize in support of such a conclusion.
1950). Consequently, throughout the course of the present studies, size has been taken into account. Such of the studies, as those of x (1936, 1938, 1939), inspire their being highly significant from the point of view of their bringing to light metabolic differences between populations from different thermal zones, suffer absolute validity on the basis of lack of consideration of the size factor.

The increasing steepness of the T-T curve in the case of smaller fishes at higher temperatures is interpreted by Wells (1935 a) as due to greater activity of smaller fishes at higher temperatures. But Wells himself could not see any difference in the locomotor activity between smaller and larger fish at higher temperatures. Hence he makes an alternative suggestion that larger fish exercise economy in expending energy for doing the same amount of work. This appears purely hypothetical. It is more likely that the temperature sensitivity of smaller fish is physiologically different from that of larger fish. Bishop (1950) is of the view that the metabolism of smaller poikilotherms responds to temperature changes such more markedly than does that of larger ones. But this interpretation is erroneously based on the absolute response of metabolism to temperature changes rather than proportional response. Belgradsk (1935, 1936) states that physiological activities, most,"
reference to processes such as respiration, development, heart rate etc., but at the same time there are cases where temperature sensitivity, as measured by $Q_{10}$, decreases with age. Hence Pammapathi Rao and Bullock (1954), reviewing the literature to date, said that most often $Q_{10}$ increases with size, implying larger individuals of a species are more sensitive to temperature changes than the smaller ones. However, it should be noted that most of the instances cited by them are amongst forms from the temperate and cold regions and it is open to question whether the same generalization holds good for tropical forms as well, particularly from the fresh water habitat. There are already a few cases from the tropics, like the earthworm, Lampito (Mejascogloss) mauritii (Saroja, 1959), the fishes, Lepidus maculatus (Parvatheswararao, 1959) and Puntius zophore (Parvatheswararao, 1960), where the trend of $Q_{10}$ in relation to size is at variance from the general trend reported by Pammapathi Rao and Bullock. In several of the studies (Wells, 1935 a; Vernberg, 1959 b) it has been pointed out that different size groups of a species may respond differently to different temperature ranges within the gradient and may be insensitive to some of the temperature ranges. On the basis of this observation they suggested that determinations made at a number of climate plant temperature levels give a better indication of the environmental metabolic response. It appears that the varying temperatures and conditions may affect the $Q_{10}$ of different species.
**Temperature and salinity.**

It has been observed (Kinne, 1956) that the effects of temperature and salinity together on animal metabolism are entirely different from any one of the two factors studied separately and that the effects of temperature and salinity on the metabolism of poikilotherms are interdependent (Prosser, 1961). Studies on these lines are but few. Only recently Dehnel (1960) has studied the effects of temperature and salinity on the metabolism of crabs, *H.igrapsus oregonensis* and *H. nudus* and Ramamurthy (1962) on the crab, *Paratelphusa sp.* freshwater mussel, *Lamellidens marginalis*; apple snail, *Pila globosa* and the freshwater cattle leech, *Hirudinaria granulosa*. In Dehnel’s work the crabs were acclimated to different temperatures and salinities, whereas in Ramamurthy’s work, as also in the present one, abrupt changes of salinity and temperature ranges have been used.

**Thermal acclimation:**

It was the old concept that the metabolism of poikilotherms is altered by environmental temperature variations. But several cases amongst poikilotherms are known, where metabolic regulation against thermal stress, in the compensatory direction, takes place, thus making them more or less independent of temperature. Though this concept dates back in the late nineteenth century, it was not until 1938 that...
The existence of metabolic compensation against thermal stress in populations from different latitudes or geographic zones has been demonstrated by several authors with reference to several rate processes like consumption, development, growth, heart beat, water pumping etc. (see Bullock, 1955 for the summary of earlier literature). In the subsequent years this phenomenon is shown to exist in a few more forms like the crab, *Lica* from different geographic zones (Tashian, 1956; Vernber, 1959 b). Of these works, those of Pampapathi Rao (1953) on the mussel, *Vittes californianus*, Roberts (1957) on the crab, *Pachygrapsus crassipes*, and Vernberg (1959 b) on the crab, *Lica* are significant in the sense that the studies are size controlled. Pampapathi Rao reports a lesser size effect on the rate of decrease in the rate of ciliary pumping of water with size in the mussels from the northern latitudes and suggests this to be the cause for the northern species growing to larger sizes than the Southern ones.

The existence of metabolic compensation in single populations on a seasonal basis has also been demonstrated under natural seasonal fluctuations as well as in the laboratory (Summer and Winter, 1934; Winter, 1935 a, b, c; Edwards and Irving, 1959 a, b; Byrnes and Irving, 1954; Sorensen, 1961).

Further, these seasonal effects are linked to the fact that
to different degrees and even the same process to different degrees at different times of the year. Emphasis on the importance of size as a factor influencing the slope and form of the -10 curve of the warm and cold adapted populations was laid by Wells (1935 b). But his results are not consistent with the generalization of Panmorathi Rao and Bullock (1954) that \( \frac{1}{10} \) increases with the habitat temperature, so that cold acclimated for \( s \) have lower \( \frac{1}{10} \) values. But there are cases which deviate from this generalization (Tashian and Fav, 1957). Scholander et al. (1953) are of the opinion that low \( \frac{1}{10} \) values need not necessarily be indices of cold acclimation. Wells (1935 c) has demonstrated an interesting case of intrinsic rhythms in Fundulus maintained round the year at a constant (high or low) temperature and yet showed the seasonal fluctuations in the metabolic rate. Similar intrinsic rhythms have also been reported by Hart (1952) in several species of fish and by Vernberg (1950 b) in the crab, Uca pugnax.

In addition to the above cases, many more have been documented by Bullock (1955) and Prosser (1955) adding weight to the fact of metabolic compensation to thermal stress. At the same time there are also cases, where the existence of compensatory changes in the metabolism in response to thermal stress are either doubtful or absent (Roberts, 1950).
general are rat or poor in metabolic compensation (Scholander and Irving, et al., 1959; Edwards, 1953; Bullock, 1956). But Dehn and Sejali (1946) clearly demonstrated the existence of a good degree of metabolic compensation against thermal stress in the American cockroach, Periplaneta americana. They further showed a clear size dependence of such a compensation; small adults acclimate to a greater degree than large ones and all nymphs acclimate more than all adults. Vernberg (1959 b) could not find any metabolic compensation in the tropic 1 crabs and he attributed this to the more or less uniform thermal setup round the year in the tropics. Recently it has been shown (Saroja, 1961) that metabolic compensation does exist in the tropical forms like the earthworm, Lampito (Xyascolestes) mauritii.

While all this material make a good case for the existence in poikilotherms of metabolic compensation to temperature as a phenomenon, the mechanism or mechanisms operating to bring about such a compensation are little understood. Bullock (1956) indicates the existence of temperature detecting mechanisms and complex rate compensating mechanisms, manifesting themselves in the shift of the R-T curves vertically or horizontally or a combination of both on acclimation at high or low temperatures (Precht, 1956; Primer, 1956). The latter process results in the alteration of the manner of metabolism and this has been discussed more extensively in the next section.
lower $\sigma_{10}$ values on cold acclimation and higher $\sigma_{10}$ values on warm acclimation. But these findings lead us no where in knowing the actual mechanisms operating to bring about metabolic compensatory changes to thermal stress whether they exist at the organism level or cellular level. With a view to investigate this aspect, it is great a detail as possible, detailed studies have been undertaken on tissue respiration, changes in water content of selected tissues, ionic composition and osmotic changes in the tissue fluids and blood and thyroid activity, in warm and cold acclimated fish.

**Tissue respiration**

It is a matter of great physiological interest to know whether the tissues respond to temperature changes and adapt to temperature stress as the whole animal does. There have been several studies on tissue respiration (Keymouth et al., 1944; Krebs, 1950; Bertalanffy and Pirozynski, 1951, 1953; Vernberg and Gray, 1953; Vernberg, 1954; Holmes and Stott, 1960). In these studies temperature was not taken into consideration but only the metabolic trends with body size have been discussed. At least in some of the tissues they could find a size trend identical with that of the whole animal. More significant are the studies on tissue respiration in relation to temperature acclimation (Norman, 1950; Puls and others, 1952; Broman and Gray, 1955; Wilcoxon and Gray, 1955; Wilcoxon, 1956; Wilcoxon and others, 1957; Wilcoxon and others, 1958; Wilcoxon and others, 1959).
have found that the brain tissue of the cold adapted polar
cod, Boreogadus saida has a higher metabolic rate and lower
$\text{Q}_{10}$ values than that of the warm adapted Idus melanotus.
Freeman (1953) could find metabolic compensation in the
brain but not in the muscle of cold and warm adapted gold
fish. Roberts (1957) reports exactly the opposite in the
crab, i.e. muscle tissue acclimating but not the brain
tissue. In the gold fish acclimation has been demonstrated
in the liver (Kber, 1958; Kanungo and Prosser, 1953).
Kirberger (1953) reported presence of acclimation in the
intact earthworm, Lumbriculus variegatus but not in the
tissue homogenate and the participating enzymes. In several
fish acclimation of the tissues was shown to be in the
opposite direction to that of the intact animal (Christophersen
and Precht, 1952; Floke, Kais and Wanjorech, 1954; Suhrmann,
1955). Further localised compensation for temperature in
the velocity of nerve conduction in the jullis has been
shown by Chatfield et al. (1953). Such findings, as these,
enhance the possibilities of the existence of the compen-
satory mechanisms at the cellular level. This assumption
appears to be nearer reality in the light of the work, in
the last few years, by Precht and his collaborators indica-
ting that unique species to respectively. Recently it has been
shown that acclimation of the liver of gold fish is present...
(Kanunjo and Prosser, 1959). Furthermore, enzyme systems were shown to adapt to temperature changes. Some of the outstanding contributions in this direction are those of Precht and his associates (Precht, 1951a, b; Christophersen and Precht, 1950a, 1952a; Kirberger, 1953b). These findings only add weight to the assumption that mechanisms for metabolic compensation may be found at the cellular level. Hence, in the present investigations O\textsubscript{2} consumption of selected tissues (brain, liver and muscle) of warm and cold acclimated fish has been studied at different temperatures.

Water content of the body is known to change on thermal acclimation (Doudoroff, 1942, 1955; Peiss and Field, 1950; Hoar and Cottle, 1952; Brett, 1952; Wickman, 1953; Suhrmann, 1955; Jankowski, 1960). It is generally believed that dehydration enhances resistance to extreme temperatures. But there are reported cases, such as the beetle, Tribolium, where the water content was shown to increase on cold acclimation and further these cold-acclimated forms were found to be more resistant to extreme temperatures (Edwards, 1958). The changes in the tissue water content may bring about corresponding changes in the "milieu interieur", such as osmotic pressure and ionic composition. There have been a few earlier studies demonstrating such systemic changes resulting from thermal stress. Schlüchter (1920) and Spengler (1923) made many contributions in this area of research.
osmotic stress, if acclimated to a high temperature. The studies of Hicklen (1953) are the most outstanding contribution in this direction. In recent years more systematic and size controller studies on the e line have been carried out in our laboratories (Panpapathi Rao and Ramachandra, 1961; Panpapathi Rao and Venkataraddi, 1962; Panpapathi Rao, 1962; Selvarajan, 1962). They could clearly demonstrate in the invertebrates, such as the crab, Paratelphusa, the freshwater mussel Lamellidens marginalis and the fish Cirrhna reba changes in osmotic pressure and concentration of chlorides and free amino acids of the blood and changes in the permeability properties on warm acclimation. It is possible that changes in the ionic composition are correlated to changes in the permeability properties. It has been shown by Halsbad (1953) that addition of magnesium and calcium to the medium considerably reduced permeability, with a consequent rise in the lethal temperature. It has been suggested that osmotic and ionic gradient between the cells and their immediate surroundings as also between the blood and the external medium may have a significant role to play in the metabolic compensation to temperature (Panpapathi Rao and Ramachandra, 1961). This ability to osmoregulate is a very essential requisite for thermal acclimation and, in most cases, at least, failure to osmoregulate is likely to be one of the main causes for death at high temperatures.
indicate the importance of the ratio between free and bound water and changes in the free water content in metabolic compensation to thermal stress (Wellbrunn, 1948; Precht, Christophersen and Hansel, 1955). In thermal acclimation amino acid content and nucleic acid content may vary (Prosor, 1958; Jankowsky, 1960) suggesting changes in protein synthesis and possibly enzyme synthesis as well. Jankowski (1960) reported increased protein synthesis in frogs on cold acclimation and that such an increased synthesis was subject to hormonal influence. Amino acids are also known to participate in osmoregulation. This has actually been shown in the bivalves Rangia cuneata (Allen, 1961) and Lasmellidens marginalis and the crab, Paratelphusa sp. (Padmanabhanaidu and Ramamurthy, 1961; Pampapathi Rao and Ramachandra, 1961). Whether it is so in vertebrates, like fishes, is not known. Ascorbic acid is supposed to have a role in thermal acclimation. There is some evidence in this direction, so far as mammals are concerned, where increased ascorbic acid synthesis on cold acclimation and increased cold resistance on administration of ascorbic acid have been shown (Beskariais, 1957). But its role in the thermal acclimation of poikiliotherms is not clear. Recently it has been shown (Ahuja-Shafi and Kalyani, 1960) that the ascorbic acid content in the tissues of several
Systemic changes, such as these, are also known to occur on acclimation to media of varying salinities. A very detailed analysis of the changes in the "milieu intérieur" on acclimation to warm and cold temperatures as well as media of varying salinities has been undertaken in the present studies towards a greater understanding of this aspect of the problem.

But then, the question remains as to the site of initiation of such metabolic regulation, whether it is cerebral or hormonal.

The role of nervous system in temperature detection is known, though decisive evidence in its support is still scanty (Bullock, 1955; Fisher, 1958). The observed facts that there is temperature selection in animals (Doudoroff, 1938; Fry, 1947; Brett, 1952; Sullivan and Fisher, 1954), capacities for which are lost after the destruction of the fore brain or rendering the peripheral sensory equipment nonfunctional by painting the body surface with a suitable narcotic (Sullivan and Fisher, 1958) and that in cases like the gastropod, Liassae stagnalis the isolated foot with the pedal ganglion showed better adaptation than the one without it (Beatty, 1934) are strong cases evidencing towards the importance of the nervous system in thermal acclimation, which Fisher (1958) emphasized. We suggest the possibility of similar acclimation consequent upon...
emanated from the reported cases like that of the skates, where, at or near the lethal temperatures, it is the functions involving the synapses that failed first resulting in the disappearance of the physiological responses of the tissues (Fattle, 1926, 1929). The importance of the brain in metabolism and metabolic adaptation to temperature has also been demonstrated by Freeman (1953) and Vernorj (1954).

The importance of hormones in metabolic regulation has long been recognised. There is an extensive literature regarding the normal influence on metabolism in the homeotherms. Amongst poikilotherms, fishes in particular have received much attention. The earlier pertinent literature in this regard has been reviewed by Pullock (1955). It is known that the thyroid shows seasonal variation in activity and that the chief environmental parameter influencing its activity is temperature (Bondy, 1951; Brown-Grant, Harris and Reichlin, and Von Euler, 1954; Brown-Grant, Harris and Reichlin, 1954; Pelcote and Stux, 1954; Fortune, 1955, 1956; Woods and Carlson, 1956; Bottari, 1957). There is documented evidence regarding the influence of the thyroid hormone on the metamorphosis and growth of several fishes and amphibians but there is no unequivocal evidence regarding its influence on the general metabolic rate (for earlier literature see Frosen, 1961; Underwood, 1961, 1962). In most fishes
cases have been reported amongst fishes, such as Salmo and Umbra, whereas the thyroid activity increases at lower temperatures, somewhat as in the case of homoeotherms (Cliverenau, 1955; Nordman, 1959). It is difficult to explain these contrasting results. It may be accounted for on the basis of specific differences and/or the critical temperature gradient required for initiating changes in the secretory activity of the thyroid, which may vary from species to species (Fortune, 1956). Similar contrasting results have been obtained on tissue metabolism (Haarmann, 1936; Buddenbrock, 1950). But in these studies with negative results, the absence of effect of the addition of the thyroid extract to the medium may be due to the delayed action of the hormone (Knox, Auerbach and Lin, 1956) or it may also be that the in vitro conditions of the experiments are unfavourable and thus antagonise the transformation of the hormone into its active state, in which condition alone it can exert its potent influence on the cell metabolism (Edelbacher and Leuthardt, 1953). Recently a definite thyroid influence on the thermal acclimation of metabolism in grass frog, Rana temporaria has been demonstrated (Jankowsky, 1960). The works of Barrington and Ats indicate that the thyroid-pituitary relations of the tetrapods are more or less identical to those of mammals and since the very early stages in the evolution of the tetrapods, the thyroid seems to have had a significant role to play in bringing about metabolic adjustments to changing environmental conditions.
But so far as fishes are concerned there is very little by way of positive evidence to substantiate such an assumption. It is most likely that metabolic adjustments to temperature changes, in the compensatory direction, are brought about through the initiation and control of these two major integrating systems of the body, namely nervous and endocrine, whose functional interdependence is well established. In the light of this known importance of hormone in metabolic acclimation to thermal stress but lack of decisive evidence in this direction, detailed studies have been undertaken regarding the thyroid activity in warm and cold acclimation as also the effects of the addition of tissue fluids of cold and warm acclimated fish (involving hormones) on the oxygen consumption of tissues of normal fish.