

THIRD MEETING OF
COMPARATIVE PHYSIOLOGISTS

6-7th December 1986.

27th November, 1986

Dear *Mike*

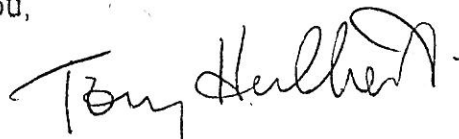
I am sending you a provisional programme for the comparative physiology meeting as well as instructions for finding the venue. If you are driving from Sydney, once you come down off the escarpment onto the coastal plain, do not take the Wollongong turnoff but rather continue to the first overpass and follow the signs to the University. Take the first entrance to the University and follow the road past the tennis courts to a yellow building. This is the location of the Biology Dept. and the venue for the meeting.

The airport bus from Mascot to Wollongong (Watts Bus & Coach Service) stops at both the Ansett and Australian Airlines terminal at 8.30 a.m. (others leave at 10.15 a.m., noon and 2 p.m.) on the Saturday and arrives in Wollongong at approximately 10 a.m. It will be met by a University minibus in Wollongong to transfer people to the University. If necessary, on the Sunday there will be a University minibus to take people to Mascot from Wollongong.

Accommodation, abstracts, dinner fee, receipts etc., will be fixed up at the registration desk.

If you need any further assistance I can be contacted at 042-270437 (work) or 042-298280 (home).

Looking forward to seeing you,


Tony Hulbert.

THIRD MEETING OF COMPARATIVE PHYSIOLOGISTS

6-7th December 1986.

The 1984 and 1985 meetings were very successful. The 1985 participants agreed that we should meet again in late 1986 as an informal group and the details of this meeting are as follows:

VENUE: Dept. of Biology, University of Wollongong.

DATES: Sat. 6th & Sun. 7th December, 1986.

PAPERS: The sessions will follow a similar format to the two previous meetings with 15 min. presentations and 5 min. allowed for discussion. Slide and overhead projection facilities will be available. Topics may be in any field of comparative or environmental physiology and research students are encouraged to attend and participate.

COST: Registration, lunch, tea and coffee. \$25 payable by Nov. 7th.

ACCOMODATION Two types of accomodation are available;

- (a) Kooloobong: Single room in 5 person share townhouse style accomodation in very pleasant surroundings. \$35 per person per night (bed and continental breakfast).
- (b) International House: single room in student dorm. communal bathrooms. \$22 per person per night (bed and breakfast).
cost of accomodation is payable at registration.

CONFERENCE DINNER: On Saturday night at a local restaurant. Estimated cost will be approximately \$20 including drinks and will be payable at registration.

TRANSPORT: There is a commercial coach service from Mascot Airport (departs 8.30am Sat) to Wollongong (cost \$10). The return trip on Sunday departs Wollongong 4.30pm and arrives at Mascot at 6pm.

Please complete the attached form and return by November 7th. If you need more forms either photocopy the attached one or contact me for more. Make cheques payable to COMPARATIVE PHYSIOLOGY MEETING. Address all correspondence to;

Dr. A. J. Hulbert,
Department of Biology,
University of Wollongong,
Wollongong, N.S.W. 2500

(telephone: (042) 270437 or 270013)

3rd Meeting of
Comparative Physiologists

Dept. of Biology,
University of Wollongong
6-7th December, 1986.

ABSTRACTS

Comparative Physiology Meeting, 6-7 December 1986.

Programme

SATURDAY

- 10.00 - 11.10 REGISTRATION and MORNING COFFEE
11.10 - 11.30 Direct uptake of calcium from the aquatic medium by Australian freshwater turtles.
Ross A. Jeffree
11.30 - 11.50 Gas exchange during voluntary submergence in the crocodile, *Crocodylus porosus*.
Jonathon Wright & Gordon Grigg.
11.50 - 12.10 Physiological studies of a burrow-dwelling shrimp, *Callinassa australiensis*.
B. D. Paterson.
12.10 - 12.30 Development of blood gas transport in the early pouch young of the tammar wallaby.
R. A. B. Holland, A. F. Rimes, A. Comis and C. H. Tyndale-Biscoe.
12.30 - 14.00 LUNCH
14.00 - 14.20 Digestion in the woodduck: a small avian herbivore.
A. Johns and T. J. Dawson
14.20 - 14.40 Digestion and utilization of hypogeous fungus by small mammals
S. J. Cork and G. J. Kenagy.
14.40 - 15.00 Rates of turnover of protein and energy in three species of wallabies.
I. D. Hume, R. G. White and J. V. Nolan.
15.00 - 15.20 Physical characteristics of the lungs of the marsupial, *Dasyuroides byrnei*.
J. Hallam and T. J. Dawson.
15.20 - 16.00 AFTERNOON BREAK
16.00 - 16.20 Influence of cold acclimation on maximal metabolism of a red-toothed shrew.
T. J. Dawson and J. M. Olson.
16.20 - 16.40 Thermal dependence of locomotor performance and muscle contractile function in a salamander species.
P. L. Else and A. F. Bennett.
16.40 - 17.00 β adrenergic receptors in the parotid gland of red kangaroos.
A. M. Beal
17.00 - 17.20 Visual acuity and retinal oversampling in cephalopods.
W. R. A. Muntz.
17.20 - 17.40 discussion of next meeting.
19.30 bus leaves campus for dinner.

SUNDAY

- 09.10 - 09.30 Effects of nest site location on thermoregulatory behaviour and incubation temperature in black noddies.
William A. Buttemer and Lee B. Astheimer.
09.30 - 09.50 Glomerular filtration rate in conscious, unrestrained starlings: effect of dehydration.
J. R. Roberts and W. H. Dantzler.
09.50 - 10.10 Influence of dehydration on nitrogen and salt excretion by the kidney of the emu.
S. Maloney and T. J. Dawson
10.10 - 10.30 Structure and function of the testicular excurrent ducts of the Japanese quail.
J. Clulow and R. C. Jones.
10.30 - 10.50 The tammar, *Macropus eugenii*, as an animal model for studies on the mammalian epididymis.
R. C. Jones, J. Clulow and G. M. Stone.
10.50 - 11.30 MORNING BREAK.
11.30 - 11.50 Temperature and thyroid function in a lizard, tortoise and crocodile and a comparison with mammals.
A. J. Hulbert, C. A. Williams and G. C. Grigg.
11.50 - 12.10 Thyroid function in laboratory-held and free-ranging *Antechinus stuartii*.
Kerry Withers.
12.10 - 12.30 A two-step model for the role of thyroid hormones in the preparation of membranes for hibernation.
M. L. Augée and A. J. Hulbert.
12.30 - LUNCH and end of meeting.

DIRECT UPTAKE OF CALCIUM FROM THE AQUATIC MEDIUM BY
AUSTRALIAN FRESHWATER TURTLES

by

Ross A. Jeffree
Environmental Science Division
A.A.E.C., Private Mail Bag
P.O. Menai, 2234

Australian freshwater turtles of the family Chelidae (Elseya dentata, Elseya latisternum, Emydura signata, Emydura australis and Chelodina longicollis) were tested for their ability to extract Ca directly from their aquatic medium by exposure to ^{45}Ca -labelled water. The subsequent presence of ^{45}Ca in a variety of tissues demonstrated the existence of this uptake pathway in all five species. E. dentata from the Ca-deficient waters of Magela Creek can still extract Ca from a water concentration as low as 0.4 mg L^{-1} .

The rate of Ca uptake is reduced in the long-necked species C. longicollis compared to similar-sized short-necked E. signata; the rate of uptake of Ca in both species is inversely related to turtle size. Separate exposures of the cloaca and bucco-pharynx with radioactively-labelled (^{47}Ca and ^{45}Ca) Ca in water, followed by tomography and analysis of dissected tissues demonstrated direct Ca uptake via both sites; however, the rate of uptake via the cloaca was ~ 20 greater than that for the bucco-pharynx.

GAS EXCHANGE DURING VOLUNTARY SUBMERGENCE IN THE
CROCODILE, CROCODYLUS POROSUS. Jonathan Wright *
and Gordon Grigg. * Dept. of Medicine University of
Tasmania. & Biological Sciences, University of Sydney.

Changes in lung and blood gas tensions during voluntary undisturbed submergence were measured in 5 juvenile Crocodylus porosus. Dives were short ($5.1 \text{ min} \pm 0.6$; $\bar{X} \pm 95\% \text{ c.l.}$) and endured aerobically with negligible production of lactate. O₂ tensions declined rapidly in the lungs and blood reflecting a high demand for O₂. Conversely, CO₂ tensions rose slowly or not at all in the lungs and blood. It is proposed that the slow rise in blood CO₂ tensions assists in the selective removal of O₂ stores from the lungs and then blood during shorter voluntary dives.

PHYSIOLOGICAL STUDIES OF A BURROW-DWELLING SHRIMP, Callinassa australiensis DANA.

B.D. Paterson
Department of Zoology,
University of Queensland, St. Lucia, Qld. 4067.

Callinassid shrimps are well adapted to living in oxygen-poor environments. Recent methods in respiratory physiology have not been applied to the study of the physiology of this group, probably because of their small and delicate nature.

The responses of oxygen consumption rate, cardio-ventilatory rate and haemolymph parameters of Callinassa australiensis during hypoxia are qualitatively similar to hypoxia adaptations displayed by many other decapods. Callinassa simply excels itself in the magnitude of these responses. This serves to highlight the capacity of the decapod respiratory system to respond to changes in oxygen concentration.

DEVELOPMENT OF BLOOD GAS TRANSPORT IN THE EARLY POUCH YOUNG OF THE TAMMAR WALLABY. R.A.B. Holland*, A.F. Rimes*, A. Comis*, and C.H. Tyndale Biscoe†. *School of Physiology and Pharmacology, University of New South Wales, Kensington, N.S.W., 2033; and †C.S.I.R.O. Division of Wildlife and Rangelands Research, Gungahlin, A.C.T.

Marsupials are born at an immature stage when compared with eutherian mammals. The Tamar Wallaby (*Macropus eugenii*) young weigh only about 400 mgm at birth which contrasts with their adult weight of 6-8 kg. The carbonic anhydrase level in their red cells is about 25-30% of the adult level before birth and rises rapidly after birth reaching 90% of the adult level at two weeks of age. The oxygen affinity of the blood was low at birth, P_{50} at 35.5°C and $pCO_2 = 34$ Torr being over 40 Torr in the first three days of life. By the age of 20 days, P_{50} had fallen below 30 Torr, close to the adult level. The effect of increased pCO_2 in raising P_{50} was low at birth but was at normal adult levels by 20 days of age. Hill "n", the index of interaction of subunits of haemoglobin with respect to oxygenation, was greater than 4 over the upper part of the O_2 -Hb equilibrium curve during the first three days of life. This high Hill "n" indicates interaction between adjacent haemoglobin tetramers. At birth at least three haemoglobins with relatively high isoelectric points were present and these were replaced during the next fortnight by a single haemoglobin indistinguishable from the adult Hb of this species.

JOHNS, A.B. and DAWSON, T.J. School of Zoology, Univ of NSW

Digestion in the wood duck: A small avian herbivore.

Although an obligate herbivore, the wood duck has few specializations to suggest that it makes significant use of the fibre component of its diet. The evidence indicates that this small bird (0.8kg) selects a high-quality diet and processes it rapidly. However, a considerable digestion of fibre does take place.

On a mixed herbage, diet apparent dry matter assimilation was 59%. The apparent assimilations of the fibre components were: hemicellulose, 73%; cellulose, 11%; and lignin, 4%. Hemicellulose digestion principally occurred in the proximal small intestine, while VFA concentrations were highest in the caeca. The caeca appeared to have several specialized roles, which distinguish it functionally from the rest of the gut.

DIGESTION AND UTILIZATION OF HYPOGEOUS FUNGUS BY SMALL MAMMALS.

By S.J. Cork, CSIRO, Division of Wildlife and Rangelands Research, Canberra, Australia and G.J. Kenagy, Zoology Department, University of Washington, Seattle, U.S.A.

The availability of nitrogen and energy from the hypogeous fungus Elaphomyces granulatus to a small North American rodent, the golden-mantled ground squirrel Spermophilus saturatus, was investigated in feeding trials. The concentration of total nitrogen was high in E. granulatus, but its digestibility was low because 50-60% of the nitrogen was associated with indigestible cell-wall components (probably chitin, but this has not yet been confirmed). In contrast to most predictions in the literature, the fungus compared unfavourably in terms of the availability of both nitrogen and energy with other food types accessible to squirrels. Mycophagy by small mammals often may relate more to nutrient yield per unit of foraging effort than to a favourable chemical composition of fungus.

RATES OF TURNOVER OF PROTEIN AND ENERGY
IN THREE SPECIES OF WALLABIES

I.D. HUME, R.G. WHITE and J.V. NOLAN
University of New England, Armidale

Basal and fed metabolic rates and whole-body protein turnover rates were measured in Thylogale thetis (red-necked pademelon), Macropus parma (parma wallaby) and M. eugenii (tamar wallaby). BMR was similar in all three species, but the tamar was lower than the other two species in fed metabolic rate ($P < 0.05$) and protein turnover rate ($P < 0.01$). This was consistent with lower voluntary feed intakes and lower maintenance nitrogen requirements of the tamar. Protein turnover rates were 23-47% lower than eutherian values. Similarly, protein synthesis made a lower contribution to fed metabolic rates in the wallabies (7-8%) than in eutherians (17-25%). Thus, compared with several eutherians, macropodid marsupials have low turnover rates of protein as well as energy, but within the macropods there is not necessarily a close link between BMR and protein turnover rate.

"Physical characteristics of the lungs
of the marsupial, Dasyuroides byrnei."

J. Hallam and T.J. Dawson, University of New South Wales,
Kensington, N.S.W., 2033.

Although they have different BMRs, placentals and marsupials have similar maximal thermogenic capabilities. We are concerned with the determinants of the ceiling for energy metabolism. As an initial step in this investigation, the transport of oxygen into the blood was examined. A study of the physical characteristics of the lung tissue of a small marsupial has been completed using light and electron microscopy. Gross anatomy, fine structure and histology of the lung tissue appear the same as those described for placentals. Morphometric analysis found that the air to haemoglobin barriers in the marsupial's lung were similar to those of placental mammals of equivalent size.

DAWSON, T.J. and OLSON, J.M. School of Zoology, Univ of NSW Kensington, NSW. and Museum of Zoology, Univ of Michigan, Ann Arbor, Michigan. USA.

Influence of cold acclimation on the maximum metabolism of a red-toothed shrew (Blarina brevicauda).

The thermogenic capabilities of B. brevicauda were examined to see if the relatively high BMR, which is characteristic of shrews, was reflected in enhanced heat production in the face of severe cold stress. A helium-oxygen environment was used to mimic severe cold.

Our results confirmed the relatively high BMR. This was 17.8 W.kg⁻¹, which is double comparable values calculated from allometric equations for placentals. Maximum sustained heat production of warm acclimated shrews was 4-5 times their BMR but this was 8-9 times "expected placental values.

Cold acclimation had a marked effect on the thermogenic capacity of B. brevicauda. Summit metabolism was increased further by some 50% to a level of 108 W.kg⁻¹ or 41 W.kg^{-0.75}. Such values are much higher than those reported for most small mammals and explain the shrews winter activity in holarctic regions

Thermal Dependence of Locomotor Performance and
Muscle Contractile Function in a Salamander species.

P.L. Else and A.F. Bennett.

The thermal dependence of locomotor performance and in vitro muscle mechanical properties were studied after acclimation at 10° and 20°C in the salamander Ambystoma tigrinum nebulosum. Performance measurements included burst and endurance capacities on land and in water. Muscle properties included measurements of isometric and isotonic parameters. No locomotor performance or muscle property showed any significant differences between acclimation groups. This species of salamander also showed no particular locomotor or muscle adjustments, other than thermal independence of burst swimming speed, to its variable and seasonally cold thermal regime. These results are puzzling, considering the prospective importance of these locomotor behaviours to survival and reproduction.

β- ADRENERGIC RECEPTORS IN THE PAROTID GLAND OF RED KANGAROOS

A.M. Beal, School of Zoology, University of N.S.W.

The involvement of β receptors in the production of saliva during sympathomimetic stimulation was investigated in anaesthetized red kangaroos using the agonists, isoprenaline, noradrenaline and salbutamol and the antagonists, atenolol, propranolol and ICI118551. Three salivary parameters were investigated viz. fluid secretion, protein concentration and magnesium concentration. During isoprenaline stimulation, all three antagonists were capable of blocking these effects, their relative potencies being propranolol > atenolol > ICI118551 (7.6:1:0.4). Salbutamol was considerably less potent than isoprenaline or noradrenaline in stimulating fluid, protein or magnesium secretion and ICI118551 was more potent than atenolol in blocking salbutamol stimulation. Consequently the red kangaroo parotid gland must have two types of β adrenoceptor which are nominally β₁ and β₂ subtypes but appear to differ from eutherian β receptors in molecular binding characteristics. The receptors are located in the end organs and not in the ducts.

Visual acuity and retinal oversampling in cephalopods

by

W.R.A. Muntz

Faculty of Science, Monash University, Clayton, Victoria

Estimates of visual acuity, in terms of the minimum separable angle for gratings, are available for Nautilus pompilius, Octopus pallidus and O. australis. For Nautilus the optomotor response was used, and the two species of Octopus were trained to discriminate horizontal from vertical gratings. Visual acuity in Nautilus lies between 5.5° and 11.25° . In the two octopus species behavioural acuity was about $4'$. In both octopuses and Nautilus the retinal grain is much finer than necessary to achieve such performance, there being around $20,000$ receptors mm^{-2} , which should in theory allow resolution of visual angles almost as low as $1'$. Retinal oversampling in cephalopods may be an adaptation for sensitivity, or a consequence of the way the eye develops.

Effect of nest-site location on thermoregulatory behaviour and incubation temperature of Black Noddies (Anous minutus)

William A. Buttemer and Lee B. Astheimer, Department of Physiology and Department of Anatomy, University of Tasmania.

On Heron Island, Black Noddies select arboreal nest-sites that range from fully-shaded and wind-protected within stands of Pisonia grandis to sites exposed to both insolation and wind in Argusia argentea at the forest edge. Over an eight-day period, we monitored egg temperature and diurnal behaviour of incubating adults from 3 nests at each of these sites. Nocturnal egg temperatures at both sites were the same (32.6°C) whereas daytime egg temperatures and midday adult body temperatures were higher in Argusia (35.6 and 41.9°C) than in Pisonia nests (33.8 and 39.5°C). The diurnal behaviour of incubating adults differs markedly between these sites both in terms of posture and episodic departures. Such differences may affect both rate and success of embryo development.

GLOMERULAR FILTRATION RATE IN CONSCIOUS, UNRESTRAINED STARLINGS:
EFFECT OF DEHYDRATION.

J.R. Roberts* and W.H. Dantzler, Department of Physiology, College of Medicine, University of Arizona, Tucson, AZ. 85724, U.S.A. (* Present Address: Department of Physiology, University of New England, Armidale, N.S.W. 2351.)

Glomerular filtration rate (GFR) was measured in 9 conscious, unrestrained European starlings, *Sturnis vulgaris* under control conditions and following a 24 hr period of dehydration. The GFR marker, ^{14}C -sodium ferrocyanide, was delivered from Alzet osmotic minipumps implanted in the peritoneal cavity. The control GFR of the birds was $2.71 \pm 0.31 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ which is significantly lower ($p < 0.001$) than the values obtained in previous micropuncture experiments for anaesthetised birds receiving an intravenous infusion. A 24 hr period of dehydration caused a significant decrease ($p < 0.001$) in GFR to $1.15 \pm 0.09 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$.

MALONEY, S.K. and DAWSON, T.J. School of Zoology, Univ of NSW

Influence of dehydration on nitrogen and salt excretion by the kidney of the Emu.

The emu possesses a kidney which is only capable of an osmolal U:P ratio of 1.5. Yet this bird ranges into Australia's arid interior. The strategy employed to compensate for this poor concentrating ability involves, 1) the excretion of waste nitrogen as precipitated uric acid/ urates, 2) the binding of cations with the precipitate so that they can be excreted in an osmotically inert form, and 3) the refluxing of urine into the cloaca-rectum before excretion, which allows extra-renal modification.

This work examined the renal physiology of hydrated and dehydrated emus. We specifically compared the composition of ureteral urine to the composition of the final excreta in these groups of birds.

STRUCTURE AND FUNCTION OF THE TESTICULAR EXCURRENT DUCTS OF
THE JAPANESE QUAIL.

J. Clulow and R.C. Jones

Department of Biological Sciences, University of Newcastle.

The excurrent ducts of the Japanese quail consist of approximately 40 efferent ducts and a short ductus epididymidis which form the "epididymal region" and a long, convoluted ductus deferens, which joins the epididymal region to the cloaca. The testes have a high rate of sperm and fluid production (sperm 3.9×10^6 /g/hr, fluid 133ul/g/hr). Most of the fluid is rapidly reabsorbed by the ductuli efferentes (92%, within 8 mins). Sperm are retained in the excurrent ducts for only 1 day and most of this time (ca. 22hrs) is spent in the ductus deferens. Sperm develop the capacity for motility shortly after leaving the testis. The main changes in inorganic ions associated with this are a doubling of the K concentration and a reduction in Ca and Mg levels. The quail excurrent ducts appear less involved in sperm maturation and storage than the homologous ducts in mammals.

THE TAMMAR, MACROPUS EUGENII, AS AN ANIMAL MODEL FOR STUDIES ON THE MAMMALIAN EPIDIDYMIS.

R.C. JONES¹, J. CLULOW¹ and G.M. STONE².

¹Department of Biological Sciences, University of Newcastle, N.S.W. 2308, and ²Department of Veterinary Physiology, University of Sydney, N.S.W. 2006.

The initial segment of the epididymis of mammals appears to be an homologous region which plays an essential role in sperm maturation. However, its effect on the luminal milieu of the ductus has not been determined since micropuncture samples from the segment are generally contaminated with stereocilia which are characteristic of the initial segment in eutherians. Consequently we have used the tamarin as a model animal since the stereocilia in its initial segment are short and do not contaminate samples.

Thyroid function in laboratory-held and free-ranging *Antechinus stuartii*

K. W. Withers.

Dept. of Biology, University of Wollongong.

Thyroidal ^{125}I release rate and thyroidal iodine content were used to determine seasonal variations in thyroid hormone secretion rate of free-ranging and laboratory-held *Antechinus stuartii*. Serum thyroxine (T_4) and triiodothyronine (T_3) levels were also measured. These parameters were also determined in cold and warm acclimated *A. stuartii* and *Mus musculus*. A seasonal variation was evident in laboratory held *A. stuartii* but this pattern differed from that in the field. From this study it is suggested that (i) eutherians and marsupials adopt different cold acclimation strategies and, (ii) the pattern of thyroid secretion rate in the field is modulated by environmental parameters such as temperature and food availability.

TEMPERATURE AND THYROID FUNCTION IN AN AUSTRALIAN LIZARD, TORTOISE AND CROCODILE AND A COMPARISON WITH MAMMALS.

A. J. Hulbert, Craig A. Williams and G. C. Grigg.*

Department of Biology, University of Wollongong and * School of Biological Sciences, University of Sydney.

Thyroid activity was examined in the lizard *Trachydosaurus rugosus*, the tortoise *Chelodina longicollis*, and the crocodile *Crocodylus johnstoni* acclimated to 20-22°C and 30-32°C. Thyroidal uptake and release of ^{125}I , plasma concentrations of T_3 and T_4 were measured as was resting oxygen consumption (at 30°C) before and after both thyroidectomy and thyroxine injections. All three species showed ^{125}I uptake at both temperatures. All three species showed no thyroidal release of ^{125}I at 20-22°C but exhibited thyroidal release of ^{125}I (and presumably hormone secretion) at 30-32°C. Plasma concentrations of thyroxine ranged from 0.55 nM to 3.24 nM and triiodothyronine from 0.14 nM to 0.51 nM. Neither thyroidectomy nor thyroxine injections had any effect on metabolic rate in 20-22°C acclimated lizards. Thyroidectomy resulted in a significant decrease in metabolic rate in 30-32°C acclimated lizards and tortoises, and thyroxine injections resulted in significant increases in metabolism in 30-32°C acclimated lizards, tortoises and crocodiles. A comparison of thyroid parameters in reptiles and mammals concluded that although the reptilian thyroid is active at high temperatures it is still considerably less active than it is in mammals.

A two-step model for the role of thyroid hormones in the preparation of membranes for hibernation.

M. L. Augee¹ and A. J. Hulbert.²

¹. School of Zoology, University of New South Wales, and ² Dept. of Biology, University of Wollongong.

The model: from mid-summer, depending on reproductive and nutritional status of the individual hibernator, falling circulating thyroxine levels lead to a lowering of the critical temperature for membrane function (T^*) from about 22°C to about 12°C. In response to 'test-drops', in which body temperature is briefly lowered but remains above 12°C, lipid metabolism is altered in such a way that T^* is further lowered to near 0°C. Rising thyroxine levels at the end of winter lead to a return of T^* to the usual mammalian level.