

Fifth
**COMPARATIVE
PHYSIOLOGY
MEETING**

School of Biological Science

University of NSW

Kensington

3-4 December 1988

**PROGRAMME
AND
ABSTRACTS**

Saturday December 3

0830-0850 Registration
0850-0900 Preliminaries

Session 1

REPRODUCTION AND DEVELOPMENT

- 0900-0920 PROLACTIN AND PROSTAGLANDIN AT PARTURITION IN
TAMMARS.
 H. Tyndale-Biscoe, L.Hinds, G.Shaw &
 T.Fletcher.
- 0920-0940 PREGNANCY DEFERRED: AN UNUSUAL ROLE FOR
PROLACTIN.
 L.A.Hinds
- 0940-1000 ORIGIN OF THE LUMINAL PROTEINS IN THE
EPIDIDYMIIS OF THE TAMMAR, Macropus eugenii,
AND REGULATION OF THEIR SECRETION.
 G. Chaturapanich & R.C. Jones.
- 1000-1020 DEVELOPMENT OF THYROID FUNCTION IN THE
TAMMAR, Macropus eugenii.
 P. Janssens & J. Grigg
- 1020-1040 DEVELOPMENT OF TISSUE METABOLIC CAPACITY IN
THE TAMMAR .
 T. Hulbert & W. Mantaj & P. Janssens
- 1040-1100 Morning tea/ coffee
- 1100-1120 WHY DO TAMMAR YOUNG LEAVE THE POUCH?
 G. Dendrinis & P. Janssens.
- 1120-1140 A THERMODYNAMIC MODEL FOR MACROPODID JOEYS:
SUPPORT FOR THERMAL INTOLERANCE AND POUCH
VACATION IN MARSUPIALS.
 P.B. Frappell
- 1140-1200 IS THE FEMALE KOALA AN INDUCED OVULATOR?
 I.R. McDonald & K. Handasyde
- 1200-1220 THE CYCLE OF THE SEMINIFEROUS EPITHELIUM OF
THE JAPANESE QUAIL, Coturnix coturnix.
 M. Lin, R.C. Jones & A.W. Blackshaw
- 1220-1240 MULTI-HORMONAL CONTROL OF AMPHIBIAN
METAMORPHOSIS
 K. Gray & P. Janssens.

- 1240-1400
Session 2 LUNCH EXCRETION, IONS, WATER
- 1400-1420 NITROGENOUS EXCRETION IN THE TERRESTRIAL CRAB
Birgus latro.
P. Greenaway & S. Morris
- 1420-1440 NITROGEN EXCRETION IN THE TERRESTRIAL CRAB,
Gecarcoidea natalis.
T. Nakamura & P. Greenaway
- 1440-1500 WATER METABOLISM IN THE WOMBAT: Lasiorhinus
latifrons and Vombatus ursinus.
P.S.Barboza and I.D.Hume
- 1500-1520 KIDNEY STRUCTURE AND FUNCTION IN WOMBATS:
Vombatus ursinus (the Common Wombat) and
Lasiorhinus latifrons (the Southern Hairy-
nosed Wombat).
J.R. Roberts, P. Barboza and I.D. Hume.
- 1520-1540 COPPER METABOLISM IN THE WOMBATS: Lasiorhinus
latifrons and Vombatus ursinus.
P.S.Barboza, B.Vanselow and P.Costigan.
- 1540-1600 Afternoon tea/coffee
- 1600-1620 MECHANISMS INVOLVED IN FLUID AND ION
SECRETION BY THE KANGAROO PAROTID GLAND.
A. M. Beal
- 1620-1640 STUDIES ON THE INTESTINAL UPTAKE AND
DISTRIBUTION OF RADIUM.
R.U. Domel & A.M. Beal
- Session 3 GENERAL PAPERS
- 1640-1700 NEURAL CONTROL OF AUTOTOMY IN Eupentacta
quinquesemita.
M. Byrne
- 1700-1720 INFLUENCES OF DIET ON pH WITHIN THE DIGESTIVE
SYSTEM OF THE FIELD CRICKET, Teleogryllus
commodus.
P.D. Cooper & N. Call
- 1720 onwards drinks followed by dinner.

Sunday December 4

Session 4

RESPIRATORY & CARDIOVASCULAR
PHYSIOLOGY

- 0900-0920 CONTROL OF VENTILATION IN Xenopus laevis.
B.K. Evans
- 0920-0940 BLOOD OXYGEN AFFINITY AND ITS RELATIONSHIP TO
BODY MASS IN DASYURID MARSUPIALS.
J.F. Hallam, R.A.B. Holland & T.J. Dawson
- 0940-1000 BLOOD RESPIRATORY PROPERTIES OF THE PRENATAL
TAMMAR WALLABY (Macropus eugenii).
E.A. Tibben, R.A.B. Holland &
C.H. Tyndale-Biscoe
- 1000-1020 PERFORMANCE OF THE HEART OF THE HAGFISH,
Eptatretus cirrhatus.
M.E. Forster
- 1020-1040 ARTERIAL COMPLIANCE IN A MACROPOD: CORRELATES
WITH HOPPING?
R.V. Baudinette & L. O'Carroll
- 1040-1100 THE EFFECT OF NEUROPEPTIDE-Y (NPY) ON THE
CARDIOVASCULAR SYSTEM OF THE CANE TOAD, Bufo
marinus.
G. Courtice

1100-1120

Morning tea/coffee

Session 5

METABOLISM

- 1120-1140 METABOLISM AND VENTILATION IN EUTHERMIC AND
TORPID HUMMINGBIRDS.
M.A. Chappell & T.L. Bucher
- 1140-1200 THERMOREGULATION IN TWO SPECIES OF SYMPATRIC
THORNBILLS.
K. Bentley.
- 1200-1220 REDUCTION OF METABOLISM DURING TORPOR.
F. Geiser
- 1220-1240 THE MEASUREMENT OF ENERGY EXPENDITURE USING
HEART-RATE IN FREE-RANGING RED KANGAROOS.
F.D. Fanning & T.J. Dawson.
- 1240-1300 CHANGES IN METABOLISM WITH BODY SIZE: A
CELLULAR EXPLANATION.
P.L. Else.
- 1300 - LUNCH

ABSTRACTS

PROLACTIN AND PROSTAGLANDIN AT PARTURITION IN TAMMARS.
H. Tyndale-Biscoe, L.Hinds, G.Shaw & T. Fletcher.
C.S.I.R.O. Div. Wildlife & Ecology, PO Box 84 Lyneham, ACT
2602.

Prolactin (Prl) and prostaglandin (Pg) are briefly elevated at parturition in tammars but are not so elevated at the equivalent stage of the non-pregnant cycle. To examine their interactions and respective roles non-pregnant tammars at day 26 were injected with either 200mg ovine Prl, 5mg Pg or saline. Prl induced a fall in progesterone but no change in Pg, whereas Pg induced a release of Prl followed by a fall in progesterone and the adoption of the birth position for the duration of elevated Pg. Thus Pg induces the release of Prl, which causes luteolysis, and birth behaviour; its own release is triggered by the fetus.

PREGNANCY DEFERRED: AN UNUSUAL ROLE FOR PROLACTIN.
L.A.Hinds
C.S.I.R.O. Div. Wildl. and Ecology, PO Box 84, Lyneham, A.C.T.,
2602

The tammar wallaby is a seasonal breeder and for almost 11 months of the year it has a quiescent corpus luteum (CL) on one ovary. The CL is inhibited by the pituitary and prolactin appears to be the specific factor. In females held on an inhibitory photoperiod there is a peak of prolactin in the morning. Within 5 days of a change to a stimulatory photoperiod the peak is absent and the CL has resumed development. If the prolactin peak is maintained artificially females remain in quiescence even when experiencing a stimulatory photoperiod. The occurrence of this brief peak of prolactin appears to be critical for the maintenance of quiescence in the tammar.

ORIGIN OF THE LUMINAL PROTEINS IN THE EPIDIDYMIS OF THE TAMMAR, MACROPUS EUGENII, AND REGULATION OF THEIR SECRETION.
G. Chaturapanich & R.C. Jones.
Dept. Biol. Sci., Univ. of Newcastle, NSW.

We have studied the origins of the proteins in the epididymis of the tammar by: (1) comparing PAGE patterns of micropuncture samples of the luminal fluids from the epididymis with patterns for rete testis fluid and blood; (2) determining PAGE patterns of perfusates after microperfusion of the duct; and (3) carrying out autoradiography of gels prepared following incubation of epididymal tubules *in vitro* in the presence of radiolabelled methionine. The effect of castration and subsequent therapy with testosterone on radiolabelled methionine incorporation has also been examined. The results indicate that the pattern of protein synthesis is similar throughout the epididymis and that castration does not cause major changes in the pattern. However, the pattern of protein secretion varied between regions of the epididymis and between

methods of determining the pattern.

DEVELOPMENT OF THYROID FUNCTION IN THE TAMMAR, MACROPUS EUGENII
P. Janssens & J. Grigg, Dept. of Zoology, ANU
& T. Hulbert, Dept of Biol., Uni. of Wollongong.

In tammar young, total plasma thyroxine (T4) is below 10nM before Day 75 of pouch life, rises to 80nmol/l at Day170, then falls to 15nmol/l in the adult. Total plasma triiodothyronine (T3) is about 0.15nmol/l before Day 100, rises to 3nmol/l by Day 200 and then falls to 1.8nmol/l in adults. Free T4 and free T3 follow the same pattern but peak at 60pmol/l and 200pmol/l respectively. Reverse T3 levels are about 0.5nmol/l in early young, rise to 1.5nmol/l at Day 180, then fall to below 0.2nmol/l in adults. Liver and kidney deiodinase activities, which are undetectable before Day 80 reach adult levels by Day 220. These findings suggest that thyroid gland function matures by Day 170 while peripheral deiodinase activity matures by Day 220. These changes in thyroid function correlate well with the metabolic changes discussed in the associated paper.

DEVELOPMENT OF TISSUE METABOLIC CAPACITY IN THE TAMMAR
T. Hulbert & W. Mantaj, Dept. of Biol., Uni. of Wollongong.
& Peter Janssens, Dept. of Zoology, ANU.

Early in pouch life, tammar pouch young have standard metabolic rates (SMR) typical of reptiles, but by the time endothermy develops at Day 180, SMR has reached the adult marsupial level. Using quantitative electron microscopy, we have measured mitochondrial parameters in brain, heart, kidney and liver from developing tammars, to assess changes in tissue metabolic capacity. In heart, kidney and brain, mitochondrial volume per cc tissue doubles during the second half of pouch life and this is the major contributor to the 2-3 fold increase in mitochondrial membrane surface area per cc tissue during this period.

WHY DO TAMMAR YOUNG LEAVE THE POUCH?
G. Dendrinis & P. Janssens
Dept. of Zoology, ANU.

Macropod young at the time of the first pouch exit will produce heat at twice the rate of their mothers, because of their smaller body size. We have suggested that this relatively high heat output by young may trigger their exit from the pouch. Observations of groups of tammar mothers with young indicates that the major factor influencing pouch vacation is the development stage of the young. However, the incidence of exit by young of similar age is increased at higher ambient temperatures. This suggests that young exit the pouch at an appropriate developmental stage but that temperature has a modulating influence.

A THERMODYNAMIC MODEL FOR MACROPODID JOEYS: SUPPORT FOR THERMAL

A THERMODYNAMIC MODEL FOR MACROPODID JOEYS: SUPPORT FOR THERMAL INTOLERANCE AND POUCH VACATION IN MARSUPIALS.

P.B. Frappell

School of Biol. Sci., Flinders Univ., South Aust.

Recently a great deal of attention has been focused on the development of endothermy in marsupial joeys (see review by Hulbert, 1988). A number of these papers speculate reasons for pouch vacation (Loh & Shield, 1977; Gemmel & Johnston, 1985; Gemmel, Cepon & Barnes, 1987; Hulbert, 1988; and Janssens & Rogers, 1988). The strongest postulate to date is for thermal intolerance between mother and young being the stimulus. However, no evidence between pouch exit and thermal distress of the young has been established. This paper examines, by mathematical modelling of the heat balance equation, the thermal balance of an *en to marsipo* joey and suggests strongly that thermal intolerance together with the ability to survive outside the pouch are the reasons for pouch vacation in macropodid and other deep pouched marsupials.

IS THE FEMALE KOALA AN INDUCED OVULATOR?

I.R. McDonald & K. Handasyde

Dept. Physiol., Monash Univ., Clayton Vic., 3168

Six female koalas were taken from a healthy, wild population at the time of breeding, fitted with radiocollars and allowed to disperse into a suitable koala-free habitat on a nearby island. Weekly blood samples were obtained. Three animals were pregnant at capture and produced pouch-young. In these, plasma progesterone was initially high and declined rapidly after birth. The others were not pregnant and plasma progesterone was low for the next 10 weeks. Four males were introduced into this habitat. Plasma progesterone in the latter three females rose and then declined over the next 5-6 weeks. Two produced pouch young. Therefore, the presence of males is required for ovulation in female koalas.

THE CYCLE OF THE SEMINIFEROUS EPITHELIUM OF THE JAPANESE QUAIL, COTURNIX COTURNIX.

M. Lin, R.C. Jones & Blackshaw

Dept. of Biol. Sci., Univ. of Newcastle, NSW.

Dept. of Physiology & Pharmacology, Univ. of QLD., QLD

As an individual cellular association in the seminiferous tubules of the bird only covers a very small area of the wall of a seminiferous tubule, several different adjacent cellular associations overlap. Consequently, it is impossible using standard histological procedures to clearly distinguish the germ cells in one association from the germ cells in an adjacent association. The problem has lead to the publication of some unusual combinations of cellular associations. We will describe a method for identifying the cellular associations in the quail and its use to determine the stages of spermatogenesis.

MULTI-HORMONAL CONTROL OF AMPHIBIAN METAMORPHOSIS.

K. Gray & P. Janssens.

Dept. of Zoology, ANU.

Thyroxine (T4) and triiodothyronine (T3) are the major hormones controlling metamorphosis in Xenopus laevis, causing shrinkage of head, tail and gut in premetamorphic tadpoles, both *in vivo* and *in vitro*. Corticosterone accelerates the effects of T4 and T3, both *in vivo* and *in vitro*, by increasing nuclear binding of T3. Testosterone inhibits the actions of T4 and T3 *in vivo* but it is ineffective *in vitro* and has no effect on nuclear binding of T3. We conclude that regulation of amphibian metamorphosis is multi-hormonal, with adrenal steroids stimulating and gonadal steroids inhibiting the metamorphic actions of thyroid hormones. Corticosteroids act locally at the tissue level, whereas testosterone probably acts centrally.

NITROGENOUS EXCRETION IN THE TERRESTRIAL CRAB BIRGUS LATRO.

P. Greenaway & S. Morris, School of Biological Science, UNSW and Dept. of Biological Science, University of Calgary.

The faeces are the principal route of nitrogenous excretion in Birgus latro accounting for 96.2% of total excretion. Uric acid comprises about 83% of the faecal nitrogen and 80% of total excretory nitrogen. It is eliminated as white faeces separate from the brown undigested food material. Loss of nitrogen by other routes (urine and as gaseous ammonia) is negligible. The midgut gland shows substantial activity of xanthine oxidase and is considered to be the site of production of uric acid and its point of entry into the gut. Clearly B. latro is capable of *de novo* synthesis of purines.

NITROGENOUS EXCRETION OF THE TERRESTRIAL CRAB, GECARCOIDEA NATALIS.

T. Nakamura & P. Greenaway

School of Biol. Science, University of NSW

The nitrogenous excretory products and their routes of nitrogen excretion have been investigated in Gecarcoidea natalis. Ammonium ion was the chief nitrogenous product excreted, comprising 91.3% of total nitrogenous excretion and urine was the major route by which NH_4^+ was excreted, accounting for 73.7% of excretion of NH_4^+ . Concentration of NH_4^+ in the urine was five times that in the blood. Purines were present in small amounts in the faeces but comprised only 3.12% of faecal excretion. No significant amount of gaseous excretion of NH_3 occurred. Total nitrogenous excretion was in the range 3.26-83.2 $\mu\text{mol-N kg}^{-1} \text{ h}^{-1}$ with a mean and standard deviation of $38.4 \pm 22.2 \mu\text{mol-N kg}^{-1} \text{ h}^{-1}$.

WATER METABOLISM IN THE WOMBAT: Lasiorhinus latifrons and Vombatus ursinus

P.S.Barboza and I.D.Hume

Dept. Biochemistry, Univ. of New England,
School of Biol. Sci. Univ. of Sydney.

The effects of water restriction were investigated in L.latifrons (Ll), from the arid zone, and V.ursinus (Vu), from a range of mesic habitats. Both species were fed a pelleted diet of straw and maize containing 68% cell wall constituents. Each wombat was restricted (Res) to 50% of its ad libitum (adl) water intake. The Adl intake of water was greater in Vu (85.8 ml. kg⁻¹.d⁻¹) than Ll (62.1). The water losses in the urine and faeces were lower during restriction but similar between species. Consequently the apparent water balance was similar between water levels and species. Urine osmolarity increased on water restriction and was higher for Ll (Adl 846; Res 1421 mosm.kg⁻¹) than Vu (Adl 484; Res 877). Although osmotic fragility of the erythrocytes was lower during restriction the plasma osmolarity and haematocrit were similar. Restriction decreased dry matter intake similarly in both species but apparent digestion of dry matter and fibre did not alter. This suggests that the arid zone species Ll, has a lower requirement for water and a greater potential to conserve it than Vu, the mesic species. This may be attributed to a difference in renal function or body water distribution.

KIDNEY STRUCTURE AND FUNCTION IN WOMBATS: Vombatus ursinus (the Common Wombat) and Lasiorhinus latifrons (the Southern Hairy-nosed Wombat).

J.R. Roberts, P. Barboza and I.D. Hume.

Departments of Physiology and Biochemistry, Microbiology and Nutrition, University of New England, Armidale, N.S.W. 2351 and School of Biological Sciences, University of Sydney, N.S.W. 2006.

Both species have an essentially unipapillate kidney. The kidney of L.latifrons (LL) has a low papillate whereas in V.ursinus (VU) the papilla is in the form of a crest. The proportion of the kidney comprising medullary tissue is greater for the xeric species LL than the mesic species VU: Relative medullary volume (as % of total kidney volume) LL 24.0%; VU 19.4%; relative medullary thickness LL 5.7; VU 4.7. Urine and plasma were collected from four fully-hydrated individuals of each species. LL had significantly higher plasma and urine sodium concentrations, a higher U/P ratio for sodium, a higher plasma chloride concentration and a lower urinary pH. Glomerular filtration rate was lower than predicted by body weight for both species (GFR in ml.(min.kg)⁻¹: LL 0.53; VU 0.47). Water restriction reduced GFR in the xeric species LL but not in the mesic species VU. LL shows adaptations in kidney structure and function which are correlated with its more arid habitat.

COPPER METABOLISM IN THE WOMBATS: Lasiorhinus latifrons and Vombatus ursinus.

P.S.Barboza, B.Vanselow and P.Costigan.
Dept. Biochem. Univ. of New England,
Regional Veterinary Laboratory Armidale,
Div. Pastoral Research C.S.I.R.O. Armidale.

A case of chronic copper (Cu) poisoning in one female L.latifrons (Ll) prompted an investigation of Cu metabolism in both wild and captive wombats of both species. Post mortem examination of the poisoned Ll revealed haemoglobinuria and generalised jaundice of the skin and membranes. The concentration of Cu in the liver was 1166 ppm.g⁻¹ dry matter (DM), many times that of wild wombats (V.ursinus (Vu) 20.8; Ll 13.2). The poisoning was attributed to feeding a pig-grower mineral/vitamin premix in all diets (35.9 ppm Cu.g⁻¹ DM) for 1.5 years. A marsupial premix was formulated to achieve similar levels of dietary Cu as pastures grazed by wild wombats (Vu 7.2 and Ll 8.7 ppm.g⁻¹ DM). Both species were fed the lower Cu diets (7.2 ppm.g⁻¹ DM) for the subsequent 1.5 years. After this period liver Cu in these wombats (Vu 13.2 and Ll 12.1) were similar to those in the wild. The total Cu stored in the liver, on the basis of metabolic body weight, was greater in Vu (103.8 µg.kg^{-0.75}) than Ll (78.9). Plasma Cu was also higher in Vu (28.3 - 20.5 µmol.l⁻¹) than Ll (6.5 - 5.2) in all cases. The apparent digestion and intake of Cu was similar between species on both diets. Although Cu intake was directly related to dietary content, the digestibility of copper was inversely related to content. Consequently the apparent Cu balance was similar between the diets. Both species have comparatively low requirements for Cu. The lower level of Cu metabolism in Ll may be an adaptation to grazing in the arid-zone where pastures are low in Cu and often inadequate for sheep.

MECHANISMS INVOLVED IN FLUID AND ION SECRETION BY THE KANGAROO PAROTID GLAND.

A. M. Beal, School of Biological Science, Univ. of N.S.W.

The currently-accepted model for secretion by salivary glands relies on transport of chloride to cause fluid and cation secretion and thus results in the initial secretion having a "plasma-like" composition. The model readily explains the production of high chloride salivas but not high bicarbonate salivas such as those produced by the parotid glands of ruminants, primates and macropods. Studies on the kangaroo parotid have shown that secretion of fluid and ions by this gland is unaffected by treatment with frusemide or bumetanide but is affected by carbonic anhydrase inhibitors and amiloride. The data indicate that, unlike other salivary glands studied so far, fluid secretion by the kangaroo parotid depends mainly on secretion of bicarbonate produced in the gland.

STUDIES ON THE INTESTINAL UPTAKE AND DISTRIBUTION OF RADIUM.
R.U. Domel¹ & A.M. Beal²
Dept. of Environmental Science, ANSTO & School of Biological
Science, UNSW.

Radium-226 is concentrated in granules within the tissue of freshwater mussels as an insoluble phosphate compound together with Ca, Mg, Ba, Fe and Al. Because mussels form part of the traditional diet of Aborigines, the transfer rates of radium-226 across the gut wall of rats, as the mussel tissue compound and as the chloride salt, are being studied to gain information for human dose calculations. Two different approaches are being used to obtain the data needed:

1. Feed trials on juvenile and adult rats using freshwater mussel tissue (dried and powdered) to provide the required dose of radium-226 have been completed for one week and two week periods whereas trials using the radium chloride salt have been completed for one week only. The results indicate that, while some of the mussel tissue radium is physiologically available to the rats, the amount is less than that available when radium is fed as radium chloride. In all experiments, the main site of sequestration was bone tissue.

2. The factors influencing the rate of radiation absorption from the intestine are being investigated in adult, adolescent and juvenile rats using isolated gut segments. In anaesthetized rats, a 10-12 cm segment of upper jejunum is isolated *in situ* by double ligation and filled with isotonic saline containing radium chloride. The transfer rate of radium across the intestinal wall is calculated for 0.5, 1, 2 and 3 hours elapsed time. The rate of uptake in juvenile rats was significantly greater than that of adult rats, the main site of sequestration under these acute conditions was again bone tissue. The possibility that calcium may competitively inhibit radium absorption from the intestine has been studied in adolescent rats. A trend towards decreased radium uptake was found when calcium chloride (1 mmol/L) was added to the gut segment.

NEURAL CONTROL OF AUTOTOMY IN Eupentacta quinquesemita
M. Byrne, School of Biological Sciences, Uni. of Sydney.

Autotomy in holothuroid echinoderms results from a rapid softening of connective tissue and is followed by regeneration of the discarded body parts within two weeks. This behaviour is an aspect of the variable tensility exhibited by echinoderm connective tissues with the extreme condition resulting in the irreversible breakdown of the extracellular matrix.

Morphological and physiological evidence revealed that the mechanism of autotomy involves a change in the binding properties of the interfibrillar matrix that allows the collagen fibrils to slide past each other. Autotomy of isolated preparations and intact specimens was elicited by electrical stimulation, K⁺, tubocurarine chloride and by a chemical agent extracted from the haemal system. The influence of these agents was blocked by anaesthetics. It appears that autotomy is controlled through an unconventional association of the nervous

system and the extracellular matrix, and the presence of an endogenous autotomy factor suggests neurosecretory or hormonal involvement.

INFLUENCES OF DIET ON pH WITHIN THE DIGESTIVE SYSTEM OF THE FIELD CRICKET, TELEOGRYLLUS COMMODUS.

P.D. Cooper & N. Call

Aust. Nat. Univ., Canberra, Aust.

The digestive process of the black field cricket of Australia (Teleogryllus commodus) has been studied to determine the pH of the various parts of the digestive system. The crop pH differs between fed and unfed animals (5.16 ± 0.30 and 6.41 ± 0.36 , respectively). The muscular proventriculus is lined with grinding teeth-like structures and is usually neutral or slightly alkaline in both fed and unfed animals (7.25 ± 0.24). The short midgut lying just posterior to the proventriculus is alkaline in both fed and unfed insects (8.01 ± 0.15). The caeca pH is slightly more alkaline in fed insects (7.74 ± 0.24 compared to 7.47 ± 0.14 for unfed animals). This work suggests that digestion may be initiated by the crop or salivary glands by acidifying the food, which is then neutralized within the proventriculus, probably by secretions from the caeca or midgut.

PERFORMANCE OF THE HEART OF THE HAGFISH, Eptatretus cirrhatus.

M.E. Forster, Department of Zoology, Uni. of Canterbury, Christchurch, New Zealand.

In a paper relating the activities of key metabolic enzymes to the power output of hearts Driedzic et al (1987) suggest that the hagfish heart is considerably less powerful than any other vertebrate heart. However, there were no direct measurements of its performance.

Isolated hagfish hearts were perfused at various preloads and afterloads. Maximal minute volumes were comparable to those recorded for elasmobranch and teleost fish and the power output is greater than was previously estimated. However, the hagfish ventricle can generate only modest internal pressures, a consequence of the remarkably low conduction velocity of the myocardium.

ARTERIAL COMPLIANCE IN A MACROPOD: CORRELATES WITH HOPPING?

R.V. Baudinette & L. O'Carroll

Biol. Sciences, Flinders Univ., Bedford Park, S.A. 5042

The profile of an animal body and its size are major determinants of arterial pulse profiles. Kangaroos have more marked secondary aortic wave reflections than other species due to a conical shape and muscular hind limbs. The effect is more marked when hopping since synchronous movement of the hind limbs and the development of high vascular impedance in the opposing muscle groups occurs when the animal lands. This paper examines the pressure profile of hopping tamar wallabies and

the compliance and microstructure of the abdominal aorta. Suggestions are made as to the resolution of potentially damaging aortic pressures in a system in which cardiac and hopping cycles are not phase-locked.

THE EFFECT OF NEUROPEPTIDE-Y (NPY) ON THE CARDIOVASCULAR SYSTEM OF THE CANE TOAD, BUFO MARINUS.

G. Courtice.

School of Physiology & Pharmacology, Univ. of NSW

NPY is a 36 amino acid peptide found co-localized in catecholaminergic nerves in the automatic nervous system of a wide range of vertebrates. In the Cane Toad, intravenous doses of NPY caused a prolonged rise in arterial blood pressure (15-30 minutes). Intermittent stimulation of the peripheral end of the cut vagus nerves caused reproducible slowing of the heart, an effect which was attenuated for at least 30 minutes following a bolus dose of NPY. The response of the heart to the cholinomimetic drug, methacholine was not affected by NPY administration, however, suggesting that the vagal attenuation is a result of pre-junctional rather than the post-junctional action. These results are similar to those found in mammals (Potter, 1985). The effects of sympathetic stimulation on vagal effectiveness were studied also.

CONTROL OF VENTILATION IN Xenopus laevis

B.K. Evans, Dept. of Zoology, Uni. of Melbourne, Parkville, Victoria, 3052.

Lung ventilation in the aquatic amphibian Xenopus laevis, unlike terrestrial anurans, involves apnoeic pauses, usually associated with diving, followed by breathing cycles of variable duration and pattern. Ventilation is stimulated by hypercapnia and hypoxia. The role of afferent input in reflex regulation of ventilation was assessed by monitoring inspiratory and expiratory volumes and blood pressure in freely-diving animals before and after surgical denervation of the lungs or carotid labyrinth. Results suggest the presence of respiratory drive from lung chemoreceptors and the carotid labyrinth, input from lung stretch receptors, and alternative mechanisms to lung or labyrinth receptors for producing hypoxic hyperventilation, ventilation-induced heart-rate changes and buoyancy adjustment.

BLOOD OXYGEN AFFINITY AND ITS RELATIONSHIP TO BODY MASS IN DASYURID MARSUPIALS

J.F. Hallam, R.A.B. Holland & T.J. Dawson.

School of Biol. Sci. and School of Physiology and Pharmacology, Univ. of NSW, Kensington, NSW.

The oxygen transport characteristics of the blood of four dasyurid species have been analyzed. Oxygen equilibrium curves

were determined for whole blood and for red cells suspended in a physiological buffer. All species demonstrated low oxygen affinity of the single haemoglobin present. P_{50} s were higher than any reported for placental mammals and correlated significantly with body mass over three orders of magnitude. In two species, the P_{50} of the red cell suspensions was significantly decreased, indicating that *in vivo* pHs were lower than 7.4. Bohr factors were measured as $\Delta \log P_{50} / \Delta \log PCO_2$ on whole blood and by standard methods on the red cell suspension. In all cases there was a significant increase in the Bohr effect measured for the red cell suspension.

BLOOD RESPIRATORY PROPERTIES OF THE PRENATAL TAMMAR WALLABY (Macropus eugenii).

E.A. Tibben, R.A.B. Holland & C.H. Tyndale-Biscoe*.
School of Physiology & Pharmacology, Univ. of NSW., Kensington, NSW., 2033. and *C.S.I.R.O. Division of Wildlife and Ecology, Gungahlin, A.C.T., Aust.

The oxygen equilibrium curves (OECs) of prenatal tamarin blood were determined at 36°C and at varying P_{CO_2} values on a modified Hem-O-Scan. The P_{50} values (P_{O_2} at 50% saturation) were 35-50 mmHg which were higher than found for the adults. This is in direct contrast to the findings in eutherians. The "Bohroid" factors, defined as $\Delta \log P_{50} / \Delta \log P_{CO_2}$, at 50% saturation (0.09 to 0.24) were lower than the adult Bohroid factor, calculated between CO_2 tensions of 34 and 64 Torr. A reversal in Bohroid effect occurred at high P_{CO_2} . The OECs climbed steeply after about 50% saturation. This produced a bend in the Hill plot in all cases. Average values for the Hill coefficient (n_H) were 2.57 and 4.95 in the lower and upper saturations respectively, at a P_{CO_2} of 34 Torr. The results were similar when the OECs were determined on red cells suspended in buffer so as to give results with controlled pH. This is the first mammal shown to be born with a blood oxygen affinity lower than that of its mother.

THERMOREGULATION IN TWO SPECIES OF SYMPATRIC THORNBILLS.

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In winter, small birds face shortened days, with possible food shortage, and high thermoregulatory demands. In this study, oxygen consumption rates and body components were analyzed in two of Australia's smallest birds (6-8g), Acanthiza pusilla and A. lineata. Differences between the two species were found in (a) oxygen consumption rates with decreasing temperatures below thermoneutrality, and (b) the quantities of insulative feathers and neutral lipid reserves. These differences may be explained by the different foraging strategies and social organization of these species.

METABOLISM AND VENTILATION IN EUTHERMIC AND TORPID HUMMINGBIRDS
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During both euthermy and torpor, oxygen consumption (VO_2) of rufous and broad-tailed hummingbirds (Selasphorus rufus and S. platycercus) is correlated with the gradient between body and ambient temperatures ($T_b - T_a$) for T_a from 0 to 30°C. Torpid hummingbirds defend a minimum T_b of about 12°C, even at much lower T_a . VO_2 during euthermy is 3- to 38- fold greater than VO_2 during torpor, depending on T_a and T_b . Changing oxygen demand is accommodated primarily by adjusting respiration frequency and, to a lesser extent, tidal volume. Oxygen extraction is highly variable in both euthermy and torpor, but is significantly reduced during torpor.

REDUCTION OF METABOLISM DURING TORPOR
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There has been some debate on whether reduction of metabolism during torpor in endotherms is strictly a physical effect of temperature or whether it involves an additional physiological inhibition. However, a recent comparative analysis on 68 species suggests that both mechanisms are used and that the pattern of reduction of metabolic rate depends on (i) the pattern of torpor, (ii) the body mass of the animal and (iii) the body temperature during torpor. Small hibernators appear to use metabolic inhibition especially at high body temperatures during torpor to reduce energy expenditure. Daily heterotherms rely on physical temperature effects without an additional metabolic inhibition.

THE MEASUREMENT OF ENERGY EXPENDITURE USING HEART-RATE IN FREE-RANGING RED KANGAROOS.
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Field Metabolic Rates (FMR) and the energetic costs of various behaviours were obtained from free-ranging red kangaroos using an individual relationship between heart rate and oxygen consumption determined for each animal in the laboratory. Measurement of heart rate from the free-ranging animals by implanted radio-telemeters yielded FMR estimates of 1.5 to 2.3 times the animal's predicted SMR. These ratios are lower than those of similarly-sized placental mammals (2.8 times SMR). Furthermore, the FMR of a placental herbivore is 2.2 times that of a marsupial herbivore of the same size, whilst the ratio between their SMRs is approximately 1.5. The application of the techniques and the implications of the results will be discussed.

CHANGES IN METABOLISM WITH BODY SIZE: A CELLULAR EXPLANATION.
P.L. Else.

As animals get larger, metabolism per unit of body mass decreases but the cellular mechanisms behind this change are obscure. So to begin to understand these underlying cellular mechanisms I have examined the amounts of energy used by the Na^+ pump on transporting Na^+ and K^+ across cell membranes in animals of different sizes. Rats of different ages (newborn-376 day or 6-915 grams) were used. The livers of these animals were studied because the liver is a significant contributor to basal metabolism in mammals. Manometric technique was used to measure weight specific oxygen consumption rates of liver slices incubated either with or without ouabain (a specific inhibitor of the Na^+ pump).

Compared to older adult animals (i.e. 376 days) the overall weight specific liver metabolism of neonates was 260% higher, this difference was even greater at 3 days of age i.e. 332%. After 3 days metabolism decreased slowly. This trend can be summarized in the following allometric equation using 3, 9, 20, 30, 50, 94, 197, 294 and 376 day postnatal animals ($N > 6$ in all age groups, oxygen consumption rates in $\mu\text{l O}_2 / \text{mg dry weight} \cdot \text{hr}$ and body mass, M in grams):

$$\text{Total Liver Metabolism} = 19.00M^{-0.26} \quad (r^2 = 0.89)$$

Liver metabolism dependent on Na^+ pump energy use changed with body size according to the following relationship:

$$\text{Na}^+ \text{ Pump Liver Metabolism} = 10.00M^{-0.35} \quad (r^2 = 0.73)$$

The remaining metabolism of the liver that is independent of the Na^+ pump was related to body size by the relationship:

$$\text{Na}^+ \text{ Pump Independent Liver Metabolism} = 8.77M^{-0.19} \quad (r^2 = 0.81)$$

The conclusions of this work are i) Na^+ pump energy use represents a large percentage of liver metabolism, ii) Na^+ pump energy use is a greater proportion of liver metabolism and a larger amount of energy in young smaller animals compared to older larger animals, and iii) Na^+ pump energy use is the major factor in determining the observed changes in overall weight specific metabolism of the liver compared to all other Na^+ pump independent liver metabolism.

The results from liver cell membrane Na^+ passive permeability experiments will also be discussed as an explanation for the measured changes in Na^+ pump energy use in animals of different ages and body size.