

Figure 2 Comparison of temperatures from MSU and ground-based measures. Monthly mean temperature anomalies from MSU (solid lines) and Alice Springs (dashed lines), and the differences (Alice Springs–MSU), for MSU-2R (upper two curves) and MSU-2 (lower two curves). Mean differences are shown (heavy lines) after January 1988 for MSU-2, and before and after June 1991 for MSU-2R. Anomalies are relative to 1988–95 means.

where the cooling in MSU-2R is largest ($-0.24\text{ }^{\circ}\text{C}$ per decade since 1979). Noise in MSU-2R over tropical oceans is a factor of two less than over tropical continents because of differences in surface emissions.

It is wrong, therefore, to assume that good agreement between a few, mainly tropical island stations validates the MSU products, and it is clear that such stations cannot adequately represent a larger-area average. A comparison with the radiosonde record at Alice Springs, Australia, after August 1987 (when a new radiosonde instrument was introduced), reveals a spurious stepwise cooling in the MSU-2R record not seen in the MSU-2 record (Fig. 2). This is consistent with the jump in the tropical MSU-2R record in mid-1991, which coincides with the NOAA-10 to NOAA-12 transition, identifiable in comparisons with tropically averaged sea surface temperatures¹.

Our argument is not that the surface and lower-tropospheric temperature trends must be identical, especially over short (17-yr) periods, but rather that the added noise in the MSU-2R record makes it unsuitable for trend analysis. Unfortunately, it is in this context that the data are most frequently referenced.

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- Hurrell, J. W. & Trenberth, K. E. *Nature* **386**, 164–167 (1997).
- Spencer, R. W. & Christy, J. R. *J. Clim.* **5**, 858–866 (1992).
- Angell, J. K. *J. Clim.* **1**, 1296–1313 (1988).
- Parker, D. E. *et al. Geophys. Res. Lett.* **24**, 1499–1502 (1997).
- Christy, J. R. *Clim. Change* **31**, 455–474 (1995).
- Christy, J. R., Spencer, R. W. & Lobl, E. *J. Clim.* (submitted).
- Reid, G. C., Gage, K. S. & McAfee, J. R. *J. Geophys. Res.* **94**, 14705–14716 (1989).
- Ross, R. J. *et al. Geophys. Res. Lett.* **23**, 3179–3182 (1996).
- Waliser, D. E. & Zhou, W. *J. Clim.* (in the press).

Frogs reabsorb glucose from urinary bladder

The amphibian urinary bladder is a bilobate, highly distensible and vascularized sac that stores fluid for use during periods of water stress¹. The organ is composed of a thin basement membrane overlaid by a selectively permeable ‘tight’ epithelium and is important in the homeostatic regulation of ion and osmolyte balance^{2,3}. We report here that glucose reabsorption from the urinary bladder permits recovery of sugar destined for excretion in the freeze-tolerant frog *Rana sylvatica*, whose unique winter survival strategy invokes extreme hyperglycaemia and ultimately, glucosuria.

We formulated the hypothesis that the urinary bladder might reabsorb glucose during studies of the wood frog, *R. sylvatica*, an anuran that is remarkably well-adapted to the cold, enduring the freezing of 65–70% of its body water during hibernation^{4,5}. Freeze tolerance in *R. sylvatica* is supported by physiological responses that mitigate cryoinjury, including a massive production of glucose⁶, which acts as a cryoprotectant⁷.

After thawing, frogs are extremely hyperglycaemic (up to 0.5 M glucose in the blood). Although some of the circulating cryoprotectant is directly reconverted to glycogen in the liver⁸, blood levels exceed the renal threshold for reabsorption and glucose is copiously excreted⁹. Glucosuria might critically limit the capacity to resynthesize cryoprotectant during subsequent freezing bouts, so we questioned whether *R. sylvatica* can effectively recover glucose

from bladder urine.

We studied glucose permeability using traditional solute-flux techniques with isolated hemibladders prepared from cold-acclimated *R. sylvatica*. We filled ligated hemibladders with a glucose-laden mucosal solution, formulated to approximate uretal urine of recently thawed frogs, and suspended them in hypertonic saline which we monitored for the subsequent appearance of glucose. The concentration of glucose in the serosal bath increased rapidly but ultimately approached the asymptote (Fig. 1). Net efflux from the bladder was strongly influenced by the initial glucose concentration of the mucosal solution (60 or 100 mM) and incubation temperature (4 or 23 °C).

To verify glucose uptake *in vivo*, we infused the bladders of live frogs with a glucose solution containing tritiated D-glucose. After incubating specimens for 4–6 h at 4 °C we scanned their tissues for the marker. Elevated radioactivity in the blood, lymph, and visceral and peripheral organs attested that the exogenous glucose had permeated the bladder epithelium and entered the general circulation. Control experiments confirmed that ligation of the bladder neck before administering glucose effected vascular isolation and confined the radiomarker within the bladder.

The concentration of glucose in urine produced by recently thawed frogs averages 80 mM (ref. 9), so reabsorption of this excreted sugar, even at the relatively low rates operative at winter temperatures (2–6 °C), seems crucial for restoring carbohydrate and energy balance during recovery from freezing.

Net efflux rates from isolated hemi-

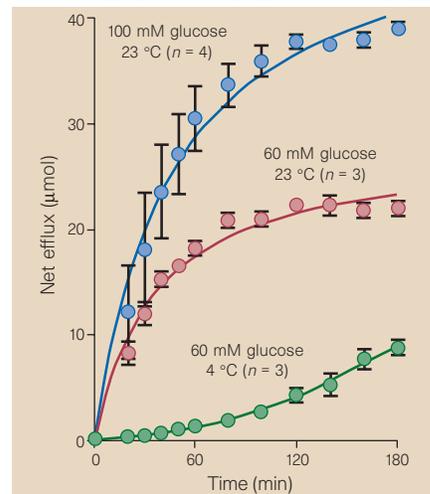


Figure 1 Time course for net glucose efflux. Efflux from isolated hemibladders of *R. sylvatica*, was based on incremental increases in glucose concentration of the serosal bath. Back flux was not determined. Hemibladders were inflated with 400 μl dilute phosphate-buffered saline (PBS; 35 mosM per kg) containing 60 or 100 mM glucose, and incubated for 180 min in a stirred serosal bath (PBS, initially 230 mosM per kg) at 4 or 23 °C. Means \pm s.e.m.

bladder preparations were similar in *R. sylvatica* and the closely related, but freeze-intolerant, common frog (*R. temporaria*) of Europe and the leopard frog (*R. pipiens*) of North America. We also noted bladder permeability to glucose in the taxonomically distant bufonid, *Bufo marinus*, and the neotenic urodele, *Necturus maculosus*.

The taxonomic diversity of species exhibiting glucose permeability of the bladder indicates that this organ is fundamental for energy balance in amphibians whose carnivorous diet contains little carbohydrate¹⁰. The urinary bladder has long been used in studies of solute and water permeability, and may prove to be an ideal model for investigating transepithelial glucose flux.

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- Bentley, P. J. *Science* **152**, 619–623 (1966).
- Boutillier, R. G., Stiffler, D. F. & Toews, D. P. in *Environmental Physiology of the Amphibians* (eds Feder, M. E. & Burggren, W. W.) 81–124 (Univ. Chicago Press, Chicago, Illinois, 1992).
- Shoemaker, V. H. & Nagy, K. A. *Annu. Rev. Physiol.* **39** 449–471 (1977).
- Costanzo, J. P., Lee, R. E. Jr, DeVries, A. L., Wang, T. & Layne, J. R. Jr *FASEB J.* **9**, 351–357 (1995).
- Storey, K. B. & Storey, J. M. *Annu. Rev. Ecol. Syst.* **27**, 365–386 (1996).
- Storey, K. B. & Storey, J. M. *J. Comp. Physiol.* **155**, 29–36 (1984).
- Costanzo, J. P., Lee, R. E. Jr & Lortz, P. H. *J. Exp. Biol.* **181**, 245–255 (1993).
- Russell, E. L. & Storey, K. B. *Cryo-Lett.* **16**, 263–266 (1995).
- Layne, J. R. Jr, Lee, R. E. Jr & Cutwa, M. J. *Herpetol.* **30**, 85–87 (1996).
- Pough, F. H. in *Behavioral Energetics: the Cost of Survival in Vertebrates* (eds Aspey, W. P. & Lustick, S. I.) 141–188 (Ohio State Univ. Press, Columbus, Ohio, 1983).

Parental age gap skews child sex ratio

The proportion of male to female births increases during and shortly after periods of war^{1,2}. We show that the age difference between parents (age of husband – age of wife) predicts the sex of the first child. We also find that in England and Wales, the mean spouse age difference increased during and immediately after the two World Wars and was strongly correlated with the sex ratio during the period 1911–52.

We obtained the age and sex of children from 301 families who attended secondary schools that recruited from a wide range of socioeconomic groups. The mean age difference D_a (age of husband – age of wife) was 2.48 years \pm 0.23 (s.e.m.) and there were 301 first-born and 260 second-born children. Among first-borns there was an excess of daughters from couples with low D_a and an excess of sons from those with high D_a ($D_a = -9$ to -1 years: 14 sons and 29 daughters; $D_a = 0$ to 5 years: 117 sons

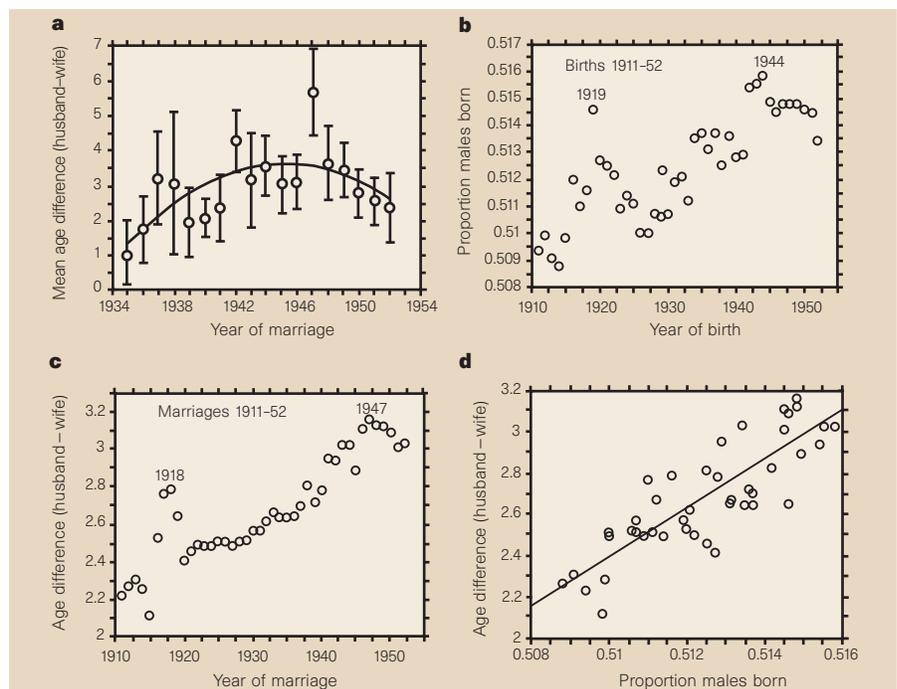


Figure 1 Parental age differences and sex-ratio statistics, 1911–52. **a**, The relationship between the mean (\pm s.e.m) of the difference in age between husbands and wives (D_a) and year of marriage (1935–52) in the Woolton area of Liverpool. There is a significant curvilinear relationship with a peak value of D_a in 1947 (second order polynomial, $y = -42.15 + 2.024x - 0.022x^2$, $F = 5.88$, $P = 0.013$, $n = 469$ marriages). **b**, Sex ratios of births registered in England and Wales from 1911–52; and **c**, D_a for marriages in the same period. **d**, Linear regression of sex ratio of births in England and Wales against D_a , 1911–52 ($r^2 = 0.68$, $F = 86.46$, $P = 0.0001$).

and 84 daughters; $D_a = 5$ to 15 years: 37 sons and 20 daughters; $\chi^2 = 11.86$, $P = 0.0027$). Among second-borns there was the opposite but non-significant tendency ($D_a = -9$ to -1 years: 22 sons and 11 daughters; $D_a = 0$ to 4 years: 93 sons and 89 daughters; $D_a = 5$ to 17 years: 20 sons and 25 daughters; $\chi^2 = 3.93$, $P = 0.14$).

The age of parents at the birth of the child has a weak effect on the child's sex³. However, multiple regression analyses with sex of child as the dependent variable and D_a and age of mother or father at birth as independent variables showed that D_a remained significantly associated with sex of child (D_a /age of mother — D_a : standardized partial regression coefficient $b_1 = -0.14$, $t = 2.35$, $P = 0.02$; age of mother: $b_2 = 0.13$, $t = 0.22$, $P = 0.83$; D_a /age of father — D_a : $b_1 = 0.14$, $t = 2.34$, $P = 0.02$; age of father: $b_2 = 0.13$, $t = 0.21$, $P = 0.83$).

Local and national patterns of D_a during the period 1911–52 (ref. 4) are shown in Fig. 1a, c. If couples do not delay the birth of their first child, D_a and sex ratio should be correlated and changes in the sex ratio should be preceded by changes in D_a . This is seen in 1914–18 but not during the Second World War (Fig. 1b, c). Registration of second and subsequent births will weaken the relationship between D_a and sex ratio so that an exact correlation is unlikely. Nevertheless a regression of sex ratio on D_a shows that the latter explains 68% of the variance of the former (Fig. 1d). Age of woman at

marriage was negatively related to the sex ratio ($b = -0.003$, $r^2 = 0.23$, $F = 12.19$, $P = 0.001$). However a multiple regression analysis with sex ratio as the dependent variable and D_a and bride's age as independent variables left D_a as the only significant correlate of sex ratio (D_a : $b_1 = 0.78$, $t = 8.26$, $P = 0.0001$; age of bride: $b_2 = -0.14$, $t = 1.51$, $P = 0.14$).

Rank in many animals is related to the sex of their offspring⁵. In humans, the elite often form partnerships with high D_a ⁶ and have more sons than daughters⁷. It may be that during wartime women prefer to marry older men with high resources and this leads to an increase in D_a . We do not know how the sex of first-borns is adjusted in relation to D_a . Women could influence the motility of sperm bearing either X or Y chromosomes or they may invest differentially in males and females *in utero* leading to higher miscarriage rates of one or the other sex.

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- Martin, W. J. *Lancet* **1**, 807 (1943).
- MacMahon, B. & Pugh, T. F. *J. Hum. Genet.* **6**, 284–292 (1954).
- Bromwich, P. *Prog. Obstet. Gynaecol.* **7**, 217–231 (1989).
- The Registrar General's Statistical Review of England and Wales, Part II Civil* (HMSO, London, 1921–1952).
- Clutton-Brock, T. H. & Iason, G. R. *Q. Rev. Biol.* **61**, 339–374 (1986).
- Kenrick, D. T. & Keefe, R. C. *Behav. Brain Sci.* **15**, 75–133 (1992).
- Mueller, U. *Nature* **363**, 490 (1993).