Letters

Diabetes Therapy

Thomas H. Maugh's Research News article "Diabetes therapy: Can new techniques halt complications?" (26 Dec. 1975, p. 1281), in which he reviews the current problems in biological and mechanical replacement of the nonfunctioning pancreatic beta cell, is restricted in several respects. Maugh disregards factors that add to the complexity of islet transplantation research and overlooks investigators who have contributed useful data to the overall experience.

One neglected problem is the severity of diabetes in the recipient of islet transplantation. Prospective human recipients will be mostly those with juvenile-type, ketosis-prone diabetes. Experimental islet transplantations done by the investigators mentioned in the article were carried out on animals with only mild or moderate (maturity onset–type) diabetes, induced by low doses of alloxan or streptozotocin. Ketosis does not develop in such animals, and thus a much more favorable metabolic milieu is created in these recipients than one would find in insulin-dependent human diabetics. Those groups who have reported experiments in ketotic animals (1–3) were not mentioned by Maugh.

Much more information is available from investigators both in this country and in Europe concerning a wider range of anatomical locations and types of tissue than is apparent from Maugh's survey. Implantation into the muscle in rats is not as ineffective as implied in the article. We presented data to the American Diabetes Association Meeting in 1974 showing the significant metabolic effect of islets implanted into the psoas muscle of severely diabetic rats (2). Impressive results have been obtained by transplantation of islets into the liver, and the syngeneic islets did not impair liver function (4). However, a rejection reaction of allogeneic tissue might severely damage this vital organ, the danger of which would far outweigh the benefits of islet transplantation to this site in humans. For this reason we have investigated the spleen as an alternative site for transplantation. Metabolic and histologic evidence (5) indicates that this is feasible. Federlin's group in Germany has successfully injected islets into the peripheral venous system of rats (3), and Usadel reported to the German Diabetes Convention last year on the successful growth of

pancreas anlage from 14-day-old rat fetuses in the subcutaneous tissue, with subsequent reversal of diabetes in the host animals.

Finally, we do not see the artificial pancreas as an "alternative" to islet transplantation, but rather as a step toward providing better control for diabetics, preceding the era of transplantation. Space-age technology will overcome some of the limitations of this device in the foreseeable future, and the great advantage that it poses no immunologic problems will make the artificial pancreas a useful tool for providing a round-the-clock supply of insulin, albeit with conventional (nonhuman) insulin. There is, however, another aspect which is not borne out by Maugh's discussion: although glucose is the most important regulator of insulin release, it is not the only one. A host of factors (hormones, amino acids, electrolytes, the autonomous nervous system) act as regulators and modulators of insulin secretion. Even with space-age technology, it would not be possible to construct a mechanism that could integrate all these factors. This is the reason why beta-cell transplantation ought to be the ultimate goal in the endeavor to "cure" the diabetic.

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Aerodynamics of the Long Pterosaur Wing

Crawford H. Greenewalt, in his letter (16 May 1975, p. 676) addressing Lawson's report, "Pterosaur from the latest Cretaceous of West Texas: Discovery of the largest flying creature" (14 Mar. 1975, p. 947), suggests that it would be valuable to consider the aerodynamic consequences of the unusually long pterosaur wing. In

his reply, Lawson (16 May 1975, p. 676) indicates that the morphological differences between birds and pterosaurs, particularly for the larger *Pteranodon* and *Quetzalcoatlus northropi* (Texas pterosaur), reflect their different modes of locomotion. In "Dynamic analysis of *Pteranodon ingens*: A reptilian adaptation to flight" (1), I reported on wind tunnel scale modeling and biomechanical analysis of *P. ingens*, which attained a 7-meter wingspan, second largest to *Q. northropi*. The results of this study show that *P. ingens* was primarily adapted to slow, flapping flight and long flight endurance. Wind tunnel analysis indicates that the reptile's soaring and gliding performance, which have traditionally been interpreted as its mode of locomotion (2, 3), was greatly inferior to that of present-day soaring birds because of limitations imposed on wing camber placement, wing attack angle, wing membrane rigidity, and inability to reduce its wing area at high flight speeds. However, the animal was structurally capable of extremely efficient, slow, flapping flight owing to wing membrane twist, metacarpal (wingfinger) rotation, centralization of its flight musculature which reduces the torque associated with pectoral muscle flexion, and its very high aspect ratio (wingspan : wing area).

Weight of the adult species was estimated from scaling up the wing loading (0.266 gram per cubic centimeter) of the morphologically and functionally similar *Eumops perotis*, a bat, which yields 15 kilograms, in agreement with Bramwell and Whitfield's (3) preferred value of 15.9 kg from anatomical estimates. Stall speed (minimum velocity for level flight) of 5 meters per second was derived from Gray's (4) equation

$$W = \tfrac{1}{2} C_L A \rho V^2$$

where C_L is the wing lift coefficient, determined from wind tunnel tests; A, the wing area; and ρ, the density of air. Maximum flight speed of 15 m/sec was estimated from the transition to the turbulent flow regime. Gray's equation is applicable to the reptile, unlike Greenewalt's (5) equation

$$W = c \, l^3$$

where l is the wingspan and c is a constant of proportionality, because C_L is the aerodynamic index for wing lifting power, while wingspan is only one of many factors that influence the lift coefficient. The aerodynamic maneuverability of the species, unlike birds, was achieved through dynamic instability, which is evidenced in the centrally located, dynamically balanced turning system of *P. ingens*, rather than a tail

as in birds or the uropotagium (tail membrane) in bats. The Late Cretaceous reptiles appear to have been highly efficient and uniquely structured slow, but maneuverable, flapping animals—the product of 150 million years of reptilian adaptation to flight.

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I read with interest the exchange between Greenewalt and Lawson regarding the wing design of the "Texas pterosaur" (*Quetzalcoatlus northropi*). Lawson is quite correct in pointing out the structural dissimilarity between the wings of birds, bats, and pterosaurs. The structure of the latter for the specific case of *Pteranodon ingens* and the corresponding aerodynamic and operational consequences have been fully discussed by Bramwell and Whitfield (*1*). No bird or bat appears to be an adequate paradigm for deducing pterosaur structure or performance.

What I find surprising in these discussions is that no one seems to have noticed that the wings of large pterosaurs appear to be direct natural counterparts of the National Aeronautics and Space Agency's high aspect ratio *cylindrically cambered* Rogallo wing, examples of which have been extensively flown as hang gliders for several years (*2*). The largest man-carrying hang glider of this type is presently the "Cronk V" with a span of 11.8 meters and loaded mass of 100 to 120 kilograms.

I have great respect for Greenewalt's earlier work (*3*) and have made extensive use of it in my own research (*4*) related to clarifying the interface between natural and low-speed, man-made flying devices (for example, hang gliders, man-powered aircraft, and sailplanes). On the basis of Greenewalt's data and mine, it appears that there is a remarkably good "square-cube law" relation between wing area (*S*, in meters) and loaded mass (*M*, in kilograms) for devices covering 12 orders of magnitude in mass (that is, small insects through large transport aircraft). The general trend for "conventional" flying devices is approximately

$$M = 15 \, S^{3/2}$$

However, for low-wing loading "ultralight" types (for example, butterflies, the zinonia seed, *Pteranodon*, and hang gliders) the corresponding relation is

$$M = (1.2 \pm 0.6) \, S^{3/2}$$

For soaring birds and sailplanes the relation is about

$$M = (10 \pm 2) \, S^{3/2}$$

The relation between mass and wing area is directly related to flying speed [$V \propto (M/S)^{1/2}$], and is thus somewhat more significant in evaluating flight characteristics than the relation between mass and wingspan, which has mainly to do with vehicle drag and lateral (roll) control characteristics. The point is that, based on the laws of applied aerodynamics, it seems the bird is a poor model on which to base pterosaur flight characteristics, while the hang glider appears to be a direct counterpart. It should be noted, however, that no current hang glider has gliding performance approaching that estimated for *Pteranodon* (*2*) (and presumably *Quetzalcoatlus*).

Provided their estimates of meteorological conditions during the Cretaceous are correct, the flight modes of the large pterosaurs deduced by Bramwell and Whitfield are well verified by 5 years of operational experience with several thousand Rogallo wing hang gliders. Two major questions require further clarification, however. (i) How did the large pterosaurs take off if no hill or cliff was available to "leap" from? (ii) What is the maximum feasible size (specifically wingspan and mass) of a device of pterosaur configuration?

Both questions can probably be resolved rather economically by construction of full-sized models, perhaps rigged as a hang glider. On the question of maximum feasible size, it should be noted that the 12-m span Cronk V has poor lateral control characteristics, although it uses a spoiler system for control rather than the pterosaur system of differential sail billow. On the basis of this consideration and the general problem of making very low speed banked turns with "large"-span wings, I tend to favor Lawson's alternative estimate of an 11-m span for *Quetzalcoatlus*.

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