Rick Weiss reports from New Orleans at the annual meeting of the American Association for the Advancement of Science

The physiology of human-powered flight

When bicyclist-*cum*-pilot Kanellos Kanellopoulos pedaled an aircraft 74 miles across the Aegean Sea in April 1988, breaking the previous record for self-powered time aloft, the engineers who designed the craft garnered a hefty dose of praise (SN: 4/30/88, p.277).

Less publicized, however, was a stunning success story about the application of theoretical physiology to a practical task. Out of the limelight, a team of metabolic mechanics put in long hours figuring how to keep Kanellopoulos' human-body engine perfectly fueled and tuned during the strenuous four-hour trip.

The so-called Daedalus 88 flight provided a wealth of information about the physiological adjustments required for human-powered flight, reports Ethan R. Nadel, a physiologist at Yale University who helped perform the computations that went into keeping the pilot airborne. Most critical was the need to sustain a constant energy output that would keep the plane moving at the 15- to 17-mph airspeed required to stay at altitude. With the plane designed to fly only 12 to 15 feet above the sea, even a brief loss of energy could spell disaster.

Using measurements taken from ground-based bicyclists, Nadel and his colleagues calculated the amount of adenosine triphosphate – the ultimate energy source in skeletal muscle – required to produce the 3 to 3.2 watts of mechanical output per kilogram of pilot weight that the plane was designed to use. Burning that much energy, they figured, would generate enough heat to raise the pilot's body temperature about 1°C every five minutes unless the heat was dissipated. The human body is a water-cooled engine, so in order to radiate that heat it was necessary to keep the pilot properly hydrated by replacing the estimated 900 milliliters of water he'd lose every hour from sweat and respiration, the physiologists predicted.

Moreover, they calculated that the pilot would run out of glycogen – the stored form of glucose in the body – after three hours, necessitating in-flight glucose supplements. From estimates that the flight would deplete 1.5 grams of the pilot's glucose per minute, they had Kanellopoulos consume 250 milliliters of a 9 percent glucose solution every 15 minutes. They added to this beverage a carefully balanced salt solution to increase fluid retention and maintain plasma volume, improving cardiac output.

In the end, Nadel says, although the flight fell about 10 meters short of its intended destination, it was an unqualified success from the physiological point of view. With the pilot's heart rate never exceeding a healthy 135 beats per minute during the 3-hour, 54-minute effort, the experiment confirmed the practical value of estimates the researchers had derived from less lofty experiments.

Still hope for adrenal-cell transplants

In a series of experimental procedures begun approximately two years ago, surgeons have removed adrenal-gland tissue from 22 people with Parkinson's disease and transplanted it into the patients' brains. Follow-up studies now indicate the treatment may have some value, says transplant team leader George S. Allen of Vanderbilt University in Nashville.

So far, neither adrenal-tissue transplants nor the more controversial transplants of fetal brain tissue (SN: 2/3/90, p.70) have shown overwhelming benefits for Parkinson's patients. On average, Allen reports, the adrenal-tissue recipients show modest improvement after the first two months, then stabilize at that level. In comparison, he notes, Parkinson's patients on standard treatment tend to worsen over the years.

Allen says he remains uncertain what prompts the improvement. Evidence from his studies suggests it involves more than a simple replacement of the neurotransmitter dopamine – present in adrenal tissues and in short supply in Parkinson's brains – and may be due in part to the presence of certain nerve-nurturing substances in adrenal tissue, he says. To find out whether something about the surgical procedure itself triggers improvement even without a transplant, Allen would like to conduct randomized trials in which some patients receive the tissues while others receive sham operations. But he says he's had trouble getting volunteers for the brain surgery without guaranteeing that they'll receive the tissue.

Relying on more than wings and prayers

For centuries, people have marveled at the pigeon's ability to find its way home over hundreds of miles of unfamiliar terrain. And for almost as long, they have sought to understand how this otherwise mundane bird accomplishes the feat.

Despite significant attention to the mystery, however, ornithologists remain largely stumped. They know homing pigeons can use the sun as a navigational instrument, but they have yet to agree on the backup systems that come into play on cloudy days. One of the more prominent theories suggested in the past two decades – that pigeons can use the Earth's magnetic field as a navigational reference – fell from grace with a 1988 research report that appeared to refute the notion (SN: 7/23/88, p.55). However, a new assessment of a large body of work from around the world suggests the birds are indeed capable of using magnetic fields – if they've learned to do so and if the magnetic forces vary enough over the flight zone.

Charles Walcott, executive director of the Cornell Laboratory of Ornithology in Ithaca, N.Y., says the reams of conflicting data about the usefulness of various sensory inputs for pigeon navigation become meaningful if one accepts that the birds may be capable of many different orientation modes. Just which mode an individual pigeon uses seems to depend upon what kind of information is available, perhaps especially during a critical imprinting period in the bird's youth.

For example, Walcott says, experiments performed with homing pigeons at a magnetized site in Rhode Island and at another near Ithaca, called Jersey Hill (whose reputation for confusing homing pigeons has led ornithologists to dub it "a Bermuda Triangle for Ithaca pigeons"), suggest the birds can indeed glean useful information from magnetic forces.

Research in Europe suggests that smell, too, can show the way home – if a pigeon has grown up in an environment that provides useful olfactory cues. Experiments in which scientists numbed some pigeons' nostrils with topical anesthetics – and others in which they either allowed or withheld olfactory stimulation during the birds' first few weeks of life – suggest pigeons can construct an "olfactory map," Walcott says. In pigeons unexposed to olfactory cues, he speculates, other means of orientation may supplant that ability.

While it's clear that pigeons prefer to orient themselves by the sun, they may also be "born with a Chinese laundry list" of second-string environmental cues they can learn to use, he concludes. "The real difficulty has been that we all assumed we were using the same beasts" in the hundreds of experiments performed over the decades. "We all argued with each other, but maybe we were *all* right."

As for how pigeons make use of magnetic information, previous research has hinted that two systems may come into play, Walcott says. A pigeon's optic nerves may respond to differences in the angles of magnetic fields, and magnetic crystals bound to nerves in the brain may detect field strength.

The incentive to understand a pigeon's sense of direction goes beyond mere curiosity, Walcott notes. More than 14,000 pigeon-racing clubs in the United States sponsor homing competitions featuring high-priced birds, upon whose wings rest the fates of substantial wagers.