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9. Facilitation of $I_{K(Ca)}$ can occur in place of depression under special conditions. If P_2 voltage is sufficiently high to limit calcium entry and accumulation, the residual Ca^{2+} left over at the onset of P_2 following a strong P_1 calcium entry can significantly elevate the total Ca^{2+} available for activation of $I_{K(Ca)}$ during P_2. Facilitation of $I_{K(Ca)}$ should be further enhanced under those conditions, because at high potentials the calcium-mediated inactivation of I_{Ca} is minimized [R. Eckert and D. Ewald, *Biophys. J.* **37**, 182a (1982)] whereas the calcium-dependent activation of $I_{K(Ca)}$is maximized (*5*, *6*). These arguments account for the facilitation of $I_{K(Ca)}$ seen above +75 mV in Fig. 1B, and reported for high test pulses by Gorman and Thomas (*6*).
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12. The term "depression" (*8*) describes the reduction in $I_{K(Ca)}$ that results from prior Ca^{2+} entry; it is not termed "inactivation" since we have no evidence that the channels carrying $I_{K(Ca)}$ are inactivated by Ca^{2+}.
13. A Hermann and A. L. F. Gorman, *Neurosci. Lett.* **12**, 87 (1979). Tetraethylammonium injection also produced some nonspecific reduction in K current which we attribute to a drop in the potassium equilibrium potential, E_K, due to a displacement of internal K^+ by TEA^+. Extracellular K^+ concentration of 20 m*M* (twice normal) further reduced E_K, and I_K, which minimized any need for series resistance correction or compensation.
14. The artificial seawater (ASW) solutions, all adjusted to *p*H 7.8 with HCl and containing 20 m*M* KCl, 0.045 m*M* tetrodotoxin, 15 m*M* tris, and 10 m*M* glucose, were made up as follows (in millimolar concentrations). ASW: 468 NaCl, 20 $CaCl_2$, 45 $MgCl_2$; 0 m*M* Ca, ASW: 468 NaCl, 65 $MgCl_2$; 0 m*M* Ca, 20 m*M* Co, ASW: 468 NaCl, 45 $MgCl_2$, 20 $CoCl_2$; 200 m*M* TEA, ASW: 268 NaCl, 20 $CaCl_2$, 45 $MgCl_2$, 200 TEA-Cl; 0 m*M* Ca, 20 m*M* Co, 200 m*M* TEA, ASW: 268 NaCl, 45 $MgCl_2$, 200 TEA-Cl, 20 $CoCl_2$.
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16. The degree of potassium current contamination remaining in TEA depends upon membrane voltage, the residual outward current increasing as the membrane voltage becomes more positive (*13*). At +10 mV and below, the contamination of inward current by simultaneous outward current is negligible as determined from tail current measurements [R. Eckert and D. Ewald, *Biophys. J.* **33**, 145a (1981); R. Eckert, in *Mechanisms of Gated Calcium Transport Across Membranes*, S. T. Ohnishi and M. Endo, Eds. (Academic Press, New York, 1981)]. Partial correction for outward current at higher potentials was made by subtracting the outward current seen in 0 m*M* Ca, ASW. The TEA-chloride (Eastman) used in these experiments was purified [R. Zucker, *Brain Res.* **208**, 473 (1981)] to remove contaminating triethylamine.
17. The I_{Ca} was now considerably smaller and more resistant than at the beginning of the experiment, due to "run down." Residual $I_{K(V)}$ was determined by repeating the experiment in 0 m*M* Ca, 20 m*M* Co, 200 m*M* TEA, ASW, and was subtracted from I_{Ca} before the latter was plotted.
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19. In the remaining experiments all test pulses were delivered at fixed voltages below +10 mV to avoid voltage-dependent changes in activation of $I_{K(Ca)}$ (*5*, *6*, *13*), and to minimize contamination of isolated I_{Ca} by potassium currents (*16*).
20. The activation of $I_{K(Ca)}$ in response to iontophoretic injection of Ca^{2+} is linear with $[Ca]_i$ as measured with injected arsenazo III (*5*, *6*). Thus, if all the calcium carried by the Ca^{2+} current into the cell remained free, close to the membrane, and available for activation of $I_{K(Ca)}$, we would expect a relation between $I_{K(Ca)}$ and $\int I_{Ca}$ such that the regression line would pass through the origin. Since time-dependent diffusion as well as rapid sequestering of Ca^{2+} occurs after its entry into the cell (*21*), some of the Ca^{2+} should be "lost" and unavailable for activation of $I_{K(Ca)}$ as time passes. The plots and their regression-line intercepts with the $\int_{t_0}^{t_x} I_{Ca}\,dt$ axis in Fig. 2, D and E, were displaced to higher values along the axis in proportion to t_x (see insets in D and E). This suggests that there is, in fact, an increasing loss of free Ca^{2+} with time, and that the percentage of Ca^{2+} lost is greater for very weak calcium currents.
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Aircraft Monitoring of Surface Carbon Dioxide Exchange

Abstract. *Aircraft-mounted sensors were used to measure the exchange of carbon dioxide above a cornfield, a forest, and a lake under midday conditions. Mean absorption values of 3400, 1200, and 100 milligrams of carbon dioxide per square meter per hour, respectively, are consistent with reported ground-based observations of carbon dioxide flux. Such information, gathered by aircraft, could be used to provide a quantitative evaluation of source and sink distributions of carbon dioxide in the biosphere, to establish a correlation between satellite data and near-surface measurements, and to monitor crop performance.*

There is much speculation on the effects of possible changes in world climate (*1*) brought about by the rising production of CO_2 from the combustion of renewable and fossil fuels. Accurate measurements made over a period of 22 years show an increase in the atmospheric CO_2 concentration from 315 to 339 parts per million (ppm) by volume (*2*), reflecting a rate that will at least double the CO_2 concentration by the mid-21st century (*3*).

Table 1. Carbon dioxide and heat flux densities for passes over corn, forest, and water around midday on 28 August 1980.

Altitude (m)	Distance (km)	CO_2 flux density (mg m^{-2} $hour^{-1}$ $\times 10^2$)	Heat flux density (W m^{-2})
		Corn	
24	1.6	−34	42
23	1.5	−14	14
25	1.5	−35	70
33	1.6	−36	70
35	1.5	−36	63
33	1.5	−47	84
Average		−34	57
		Forest	
33	10.9	−8	56
34	10.9	−10	28
48	11.4	−11	42
47	10.5	−12	42
61	10.4	−18	56
60	10.7	−14	42
Average		−12	44
		Water	
31	3.3	−3	28
28	3.3	3	21
29	3.3	−4	14
Average		−1	21

On this basis, some climatological models predict a significant rise in the mean temperature (*4*), altered rainfall patterns, and the eventual desertification of some major food-producing regions such as the central North American Plain. Other models predict minor temperature change (*5*), better crop water use, more rapid crop development, and ultimately higher crop yields (*6*).

Although records of the oil, gas, coal, and forest industries make possible a reasonable estimate of CO_2 production, it is far more difficult to quantify the net CO_2 exchange with living biota (*7*), soils (*8*), and oceans (*9*). Thus, reliable measurements must be made over seas, forests, and cultivated and uncultivated agricultural land in order to evaluate the role of these ecosystems in the carbon cycle. Clearly, large areas are involved, and a rapid means of gathering data must be used.

To this end, we successfully used an aircraft-mounted flux-measuring system based on the eddy correlation technique to monitor CO_2 exchange over various ecosystems. This system required the continuous recording of CO_2 concentration and vertical air velocity. The aircraft, a Twin Otter, was chosen for its ability to fly at low altitudes and low speeds. Its standard instrumentation (*10*) includes a temperature sensor, a gust-probe assembly for the determination of the high-frequency component of air motion, and a Doppler radar assembly for the determination of the low-frequency component. In all, 32 parameters were recorded, 16 times per second, and all

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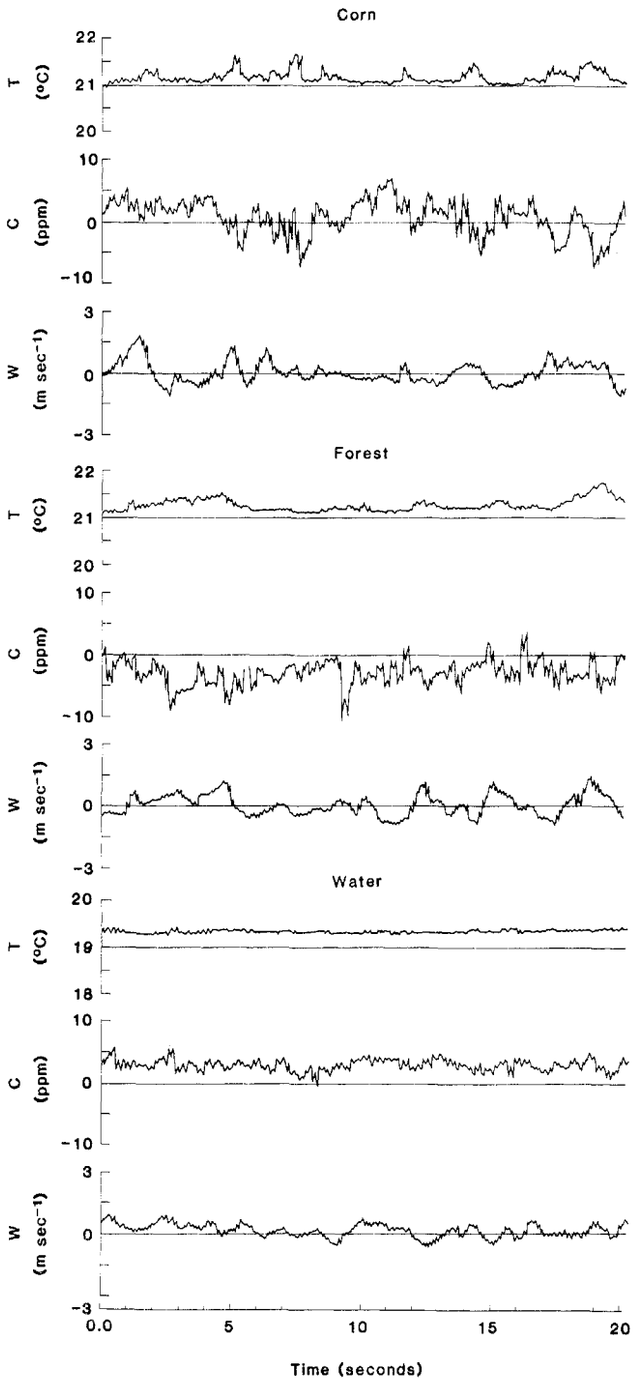
signals were filtered with identical 4-Hz low-pass filters to avoid aliasing errors.

A newly developed open-path CO_2 analyzer (*11*), which is based on the differential absorption by CO_2 of infrared radiation at wavelengths of 4.3 and 4.7 μm, was mounted through the escape hatch in the cabin roof. With the radiation source and detector located just inside the aircraft and the infrared beam reflected by a mirror assembly 0.75 m above the cabin roof, the in-air path length is 1.5 m. The instrument has a time constant of 0.08 second, and its precision is limited by a root-mean-square noise equivalent to 0.3 ppm by volume at an airspeed of 50 m sec^{-1} and a 0.25-ppm limitation inherent in the data-recording procedure. The 10-m separation between the gust-probe assembly and the CO_2 analyzer introduces a 0.2-second lag between wind and CO_2 data. However, such a lag would affect only the flux computations from eddies near the high-frequency (4-Hz) cutoff which, as analysis of wind and temperature spectra showed, contribute negligibly to the transfer.

Repeated test flights over cornfields, forests, and water (Table 1) were conducted on 28 August 1980 in order to evaluate the resolving power of the experimental system and the reproducibility of the data. Mean CO_2 absorption values obtained from these measurements were 3400, 1200, and 100 mg m^{-2} $hour^{-1}$ for corn, forest, and water, respectively. These significant differences are attributable mainly to photosynthesis under the reasonably well-mixed conditions indicated by the vertical wind data in Fig. 1. The data are compatible with



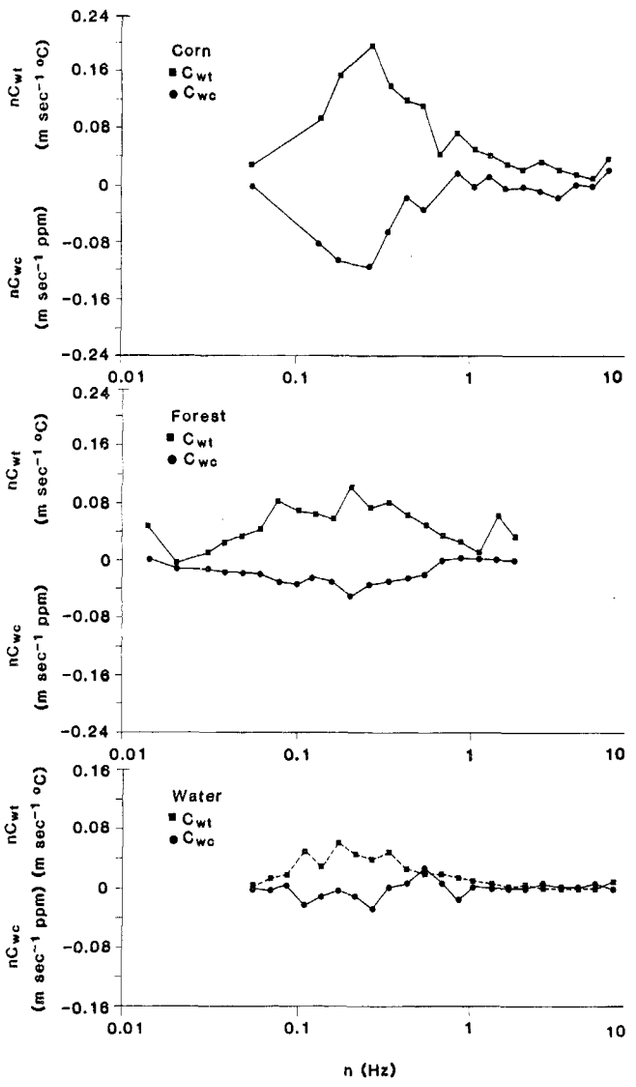


Fig. 1 (left). Simultaneous records of air temperature (T), CO_2 concentration (C), and vertical velocity (W) at approximately 30 m above corn, forest, and a water surface on 28 August 1980. Fig. 2 (above). Average cospectra of the CO_2 concentration and vertical velocity (C_{wc}) and of temperature and vertical velocity (C_{wt}) for the data presented in Table 1.

flux measurements reported in the literature over similar ecosystems (*12*).

Simultaneous traces of the fluctuations in air temperature, CO_2 concentration, and vertical velocity as measured above these surfaces are shown in Fig. 1. Over the corn crop, upward-moving eddies were warmer than downward-moving eddies by as much as 0.6°C and the CO_2 concentrations of the upward-moving eddies were lower by as much as 6 ppm, signifying the release of heat and the absorption of CO_2 by the corn crop. Fluctuations in the CO_2 concentration were slightly smaller over the forest and much smaller over the water.

Individual and average CO_2 heat flux densities over these surfaces are presented in Table 1. Nonsteady-state conditions may contribute to some of the deviations, particularly for the necessarily short runs over the cultivated fields. In order to evaluate the effect of short sampling time, data from 3-minute measurements over the forest were treated as six 30-second periods. The lack of significant difference indicates that, over extended surfaces, at least 30-second measurements might be adequate. Over short fields with limited fetch, the effects of nonsteady state and spatial inhomogeneity on short-term sampling need to be further investigated, and a displacement equation (*13*) may have to be used. The slight tendency for flux values observed over forest to increase with height might be attributed to the fact that at higher altitudes the contribution of more photosynthetically active surrounding vegetation was also measured.

Cospectral analysis of the time series for fluctuations in CO_2, temperature, and vertical wind can be used to show the range of eddies primarily responsible for the observed fluxes. From the areas under the curves in Fig. 2, which are proportional to the fractional cospectra, it can be seen that at the given altitudes most of the contributions to the flux are from eddies varying in size from 50 to 1000 m. This is well above the minimum eddy size of 10 m that can be resolved by the aircraft's recording system. Peaks in the wind-CO_2 (C_{wc}) cospectra correspond to valleys in the wind-temperature (C_{wt}) cospectra, indicating the inverse directional relationship and scale similarity between the transfer of CO_2 and heat.

The results presented in this report demonstrate the feasibility of studying CO_2 exchange over extensive areas with the use of aircraft-mounted instrumentation. It is expected that future work in this area may well allow large-scale monitoring of biomass production in agriculture and forestry, leading to better yield estimates and to a deeper understanding of the role of the biosphere in the global CO_2 cycle.

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Autoradiographic Evidence for a Calcitonin Receptor on Testicular Leydig Cells

Abstract. *Previous studies have indicated that there is a relation between testicular function and adequate concentrations of zinc in testicular cells, and that calcitonin alters cellular zinc transfer in the testis. The present studies provide autoradiographic evidence that calcitonin binds in vivo to the cell membrane of testicular Leydig cells. The data thus confirm the presence of the testicular cell membrane calcitonin receptors that were previously demonstrated indirectly by Scatchard analysis of data collected from binding studies.*

The presence of a homeostatic mechanism for maintaining zinc concentrations in the serum or tissues has been suggested by many lines of evidence (*1, 2*). Recent studies in our laboratory suggested the possibility of a hormonal influence on tissue zinc homeostasis. Calcitonin, a hormone with a definite, but diffuse, role in calcium metabolism, has been demonstrated to have a specific effect on cellular zinc transfer in the testis, a tissue that undergoes atrophic change in the absence of adequate zinc nutrition (*3–5*). Since these effects of calcitonin appear to be biologically specific and significant, it should be possible to demonstrate the presence of testicular cell membrane receptors for calcitonin, with characteristics similar to those of receptors for other peptide hormones. In previous studies (*6*) we did, indeed, demonstrate the presence of such receptors, although we did not identify the cell type responsible for the binding. In this report we describe studies that confirmed those findings and enabled us to identify the cell type whose cell membrane contains the calcitonin receptor.

Male rats of the CD strain (Charles River; 120 to 140 g) were thyroidectomized and parathyroidectomized 5 to 7 days before they were used for the study. One day before the study, we labeled synthetic human calcitonin (Beckman) with ^{131}I using the bead-coupled lactoperoxidase method (Bio-Rad, Inc.) according to the supplier's recommended procedure. The free iodine was separated on a Sephadex G-50 microcolumn. On the day of study, the animals were anesthetized with pentobarbital and both the renal arteries and veins were ligated. One microcurie of either [^{131}I]calcitonin or ^{131}I alone was then injected intravenously into the inferior vena cava. Fifteen minutes after injection, a large-bore needle was placed in the left ventricle and the animal was perfused with normal saline for 2 minutes. The infusate was then changed to a solution containing 2.4 percent glutaraldehyde and 0.4 percent paraformalde-

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