Rumor and Confusion Follow Ozone Theory Revision

Ruth Reck has been restructuring the earth's atmosphere again—a preoccupation not nearly as implausible as it sounds for a General Motors physicist. With commands typed neatly on key-punched computer cards, she wipes out massive amounts of ozone from the stratosphere or shifts the bluish gas around to different levels. Her latest set of models predicts some very interesting atmospheric behavior, and, moreover, promises to restructure another system—the current morass of confusion and uncertainty that was once an orderly theory of ozone destruction by fluorocarbons.

That theory and the supporting evidence, gathered by balloon, jet and infrared spectrometer, seemed so airtight last month that rumor ran wild in Washington of an imminent ban on nonessential uses of fluorocarbons 11 and 12. Rumor is running rampant again this month, that the theory was wrong, industry was right, the ozone layer is saved and fluorocarbons deserve an official reprieve. Or the inverse of all those statements, depending on who's talking. Committees impaneled by the National Academy of Sciences and a federal interagency task force called "IMOS" are meeting hastily to reconsider tentative recommendations. Scientists are shuttling in and out of the city to testify before the committees on new theories, models and evidence. And the founder of the original fluorocarbon-ozone destruction theory, F. Sherwood Rowland, nervously churns out yet more equations.

Rowland and co-worker Mario Molina proposed the now famous theory two years ago and, like the fluorocarbons themselves in the lower atmosphere, it had remained inert to serious attack until now. True to innovative form, Rowland, Molina and John E. Spencer of the University of California at Irvine made the first substantive revision in the theory themselves earlier this year (SN: 3/20/76, p. 180).

Analyses, models and projections made since have touched off the latest paroxysm of speculation. Ruth Reck's study, reported in the May 7 SCIENCE, was begun and submitted before Rowland revised the theory, but, coming at this point, may shed considerable light on the murky situation as well as add force to the argument that all is *not* well with the ozone layer, theory revision notwithstanding.

Reck wanted to calculate the effects of ozone depletion on earth surface temperatures. Previous researchers had predicted that complete removal of ozone wouldn't really change the earth's surface temperature much (less than 1°C) but would completely eliminate the tropopause. The boundary between the troposphere and the stratosphere divides cold air below from warmer air above. This layering effect, in large part, controls weather and climate. Reck used a more sophisticated model of the atmosphere for her study. Plugging in ozone depletion rates from 10 percent to 100 percent, she, too, observed only a small surface temperature change up to 90 percent ozone depletion. Only at 100 percent was the tropopause eliminated.

This model, she told SCIENCE NEWS, was "reassuring"; not even large ozone depletions—and certainly not the small ones estimated for current fluorocarbon release rates—would likely lead to drastic changes in surface temperature. But then Reck did a second, and ultimately disquieting, experiment. She lifted the "ozone profile" in her model. This profile, she explains, is the amount of ozone at each altitude. By arbitrarily changing the height of the maximum amount of ozone (the "bulge" in the ozone profile) but without removing any of the ozone, she saw a larger change in surface temperature than before.

Such a shift in the ozone profile, unfortunately, is predicted by both the old and new Rowland theories. And herein lies the importance of Reck's study for the current confusion. In Rowland's new theory, chlorine nitrate ($ClONO_2$) would be formed after reactive chlorine is kicked loose from fluorocarbons. It would then tie up the chlorine and prevent it from destroying as much ozone as originally predicted. Just how much prevention is afforded by $ClONO_2$, however, is a major point of contention now. Some industry-funded "modelers" calculate that with $ClONO_2$ in the picture, 90 percent less ozone would be destroyed. This practically exonerates the fluorocarbons. Others, however, like Rowland and Paul Crutzen of the National Center for Atmospheric Research in Boulder, Colo., calculate a 50-60 percent reduction in ozone depletion—less disastrous, but still a problem. The solution to this is still up in the air, so to speak.

The change in ozone profile, however, remains in the new model. $ClONO_2$ would not function effectively as a chlorine-atom-catcher at high altitudes (above 35 kilometers) due to the penetration of strong ultraviolet light. Thus, fluorocarbons reaching that height might break down a predicted 35 to 40 percent of the ozone above 35 km. Looking at a graph of the new ozone profile, were this upper stratospheric depletion to occur, Crutzen said, "This looks like the profile from another planet." And as Ruth Reck found, ozone profile changes theoretically could influence temperatures more strongly than even severe ozone depletion.

This new emphasis suddenly makes the fluorocarbons potential villains on the climatic scene to a greater extent, and villains on the skin cancer-crop damage scene to a lesser extent. And the uncertainty of the new theory and calculations now places a large part of the prediction problem in the hands of meteorologists—a group already saddled with such a complex, dynamic and poorly understood system that reliable prediction won't be forthcoming for a decade.

The co-chairman of the IMOS task force, Carol Pegler, told SCIENCE NEWS that reevaluation is going on now and that the "troubling uncertainties raise new questions and research needs. But," she says, "as far as I am personally concerned right now, nothing in the new information removes the seriousness of the old."

Crutzen, one of the most highly regarded ozone researchers, told SCIENCE NEWS, "I am sure that this industry will be phased out—if not for biological reasons, then climatological ones. There is no doubt that fluorocarbons will alter the ozone in some way; the longer we go on, the more it will be altered. Perhaps a two to three year phase-out is a reasonable compromise, I don't know. That's not my area. But I would be happiest if it were to go as soon as possible." □

Mental abilities: Sex or maturation rate

Males and females differ in many ways, including performance on certain tests of mental ability. Males tend to excel on tests of spatial skills while females usually score better on tests of verbal ability (fluency, articulation and perceptual speed). The most obvious reason for these differences would seem to be gender, but there may be another explanation. In the May 7 SCIENCE Deborah P. Waber of the department of psychiatry at Children's Hospital Medical Center in Boston suggests that rate of maturation, rather than sex, might be responsible for some of the observed differences between the sexes in mental abilities.

Females generally attain physical maturity at an earlier age than males. And this biological fact could be related to mental abilities. Waber hypothesized that early maturers, whether male or female, would tend to score higher on verbal tests, and late maturers would do better on spatial tests. Girls 10 and 13 years old and boys 13 and 16 years old from a middle-class white population were examined medically and rated as early or late maturers according to secondary sex characteristics (a good indicator of general physical growth). The sample of 80 consisted of ten early and late maturing girls and boys at both age levels.

Three tests of verbal ability and three of spatial ability were administered to the subjects. The specific tests used were ones for which sex differences in the expected direction had been reliably reported. This time, when the subjects were rated along a continuum of maturation, gender did not make a difference. Waber's predictions were confirmed. Early maturers, regardless of sex, scored better on verbal than spatial tasks. Late maturers scored better on spatial than verbal tasks. The earliest maturing group (early maturing girls) and the latest maturing group (late maturing boys) showed the greatest differences. This might suggest that verbal scores increased while spatial scores decreased for early maturers (and vice versa for late maturers), but Waber found that performance on spatial tasks accounted for most of the difference between scores. Verbal ability was not significantly related to rate of maturation and will have to be accounted for by other factors.

One possible explanation for the differences between male amd female abilities is hemispherical organization. The left hemisphere is said to be lateralized or specialized for speech and language functions. But speech is not completely confined to the left hemisphere, and there are degrees of lateralization. The theory is that the more language is confined to the left hemisphere, the less it will interfere with the spatial abilities of the right hemisphere. And recent studies do indicate that speech is more lateralized among adult males than adult females. But this finding, too, might be a result of rate of maturation rather than of sex, according to Waber's findings. The early and late maturers in her sample were tested for lateralization, and the late maturers were found to be more lateralized for speech. Again, sex did not seem to be the deciding factor.

Waber says that this concept (rate of maturation rather than sex) might also apply to other seemingly sex-related behaviors not examined in her study. She concludes that "the rate of maturation (or its implicit physiological correlates) may play an important role in the organization of higher cortical functions." □

Where has my little charm gone?

"Blatant is better than latent" is a slogan that appears on certain lapel buttons. It was not originally intended to apply to particle physics, but it might fairly represent the attitude of physicists toward the property of elementary particles that they call charm. For numerous theoretical reasons they want charm to exist. Recently experiments have discovered a series of unexpected, oddly behaving particles, and many theorists have concluded that these new particles contain hidden or latent charm. But to prove the existence of charm satisfactorily physicists must discover particles with overt or observable charm. That, so far, they cannot do, and their dismay was evident at last week's meeting of the American Physical Society in Washington.

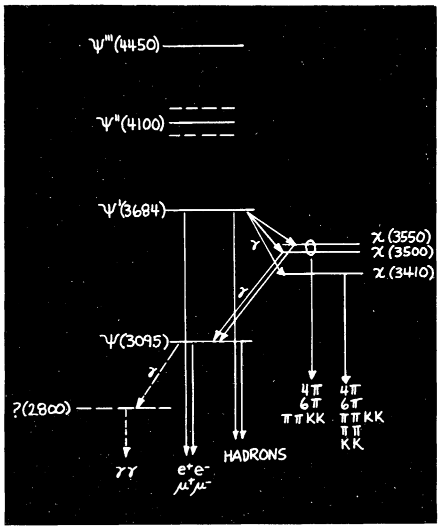
To make plain the importance of charm, a little historical excursion is in order. As physicists began to discover upwards of 100 "elementary" particles, they began to feel that that was too many to be really elementary. Underlying this multitude must be a simpler, more fundamental order of being, a few simple components out of which the whole menagerie could be constructed. To these fundamentals was given the name quark.

To explain the common, well-behaved particles such as neutrons or protons requires two quarks (and their corresponding antiquarks) designated "up quark" and "down quark" or "neutron quark" and "proton quark" depending on whether one uses Californian or eastern American terminology. But at the point that the quark theory began there was already known a class of less straightforwardly behaved particles called strange particles (because of their odd behavior). To account for some of the things the strange particles did, a characteristic called strangeness was put into the theory. To have particles that possessed strangeness and behaved according to the rules that were empirically deduced for it, required a third quark in the theory, called alternately "strange," "lambda" (after a particular one of the strange particles), or "sideways."

That's about where the quark theory began. But theoretical physicists never stop for long. As it happened they were working on a unified field theory, an attempt to unite the four classes of force or interaction known to physics (which are called strong, electromagnetic, weak and gravitational) into a single description. The most successful chapter of this work involved the unification of weak and electromagnetic interactions. To accomplish it required a serious change in the theory of the weak interaction. Each interaction governs a certain group of radioactive decays and particle collisions involving those particles that respond to its forces. Until a year or two ago a characteristic of the weak interaction was that its processes always involved the exchange of a unit of electric charge between the participants. (In the jargon, such processes are called charged currents.) But to unite the weak interaction with electromagnetism the theorists had to introduce weak-interaction processes that did not involve electric-charge exchange (called neutral currents).

Now it happens that the charged-current weak processes always involve a simultaneous change in strangeness if a strange particle happens to take part in them, but the neutral currents do not change strangeness. To prevent the change of strangeness in the latter case, theorists had to postulate a new characteristic that would hold the strangeness fixed. This, they called arbitrarily "charm." Since none of the three quarks in the theory had any charm, a fourth, charmed quark had to be put into the theory to be a constituent of particles that had charm. So now we have four quarks, u, d, s, and c.

Just as there are particles that exhibit electric charge and behave according to rules appropriate for it, and just as there are particles that exhibit strangeness and behave according to the rules appropriate for that, so there ought to be particles that exhibit charm and behave according to its rules. About two years ago experimenters began to set up arrangements to look for them. Meanwhile, came the quite unexpected discovery of a gang of particles now collectively called "psionic matter," which may or may not be the repository of latent or hidden charm.



Psionic spectrum: Masses, decay modes.

The first of these new particles, called psi in the west and J in the east was found simultaneously at the Stanford Linear Accelerator Center in California and at Brookhaven National Laboratory in New York. It was heavier than any other known particle. For something so heavy it had a long lifetime compared to the lifetimes of other heavy particles.

In something less than a year and a half, since November 1974, at least eight other particles related to the first psi have been found, mostly in the products that appear after the annihilation of colliding electrons and positrons. Collectively they have been dubbed "psionic matter." A spectroscopic chart can be drawn to show how they decay, sometimes into one another, sometimes into previously known particles.