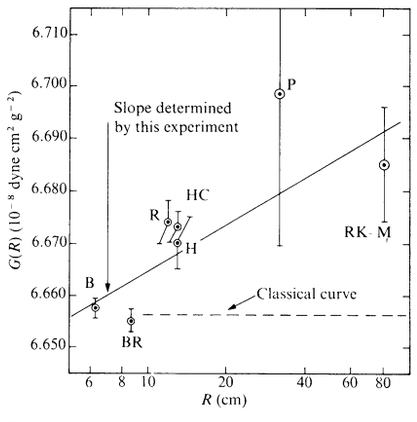
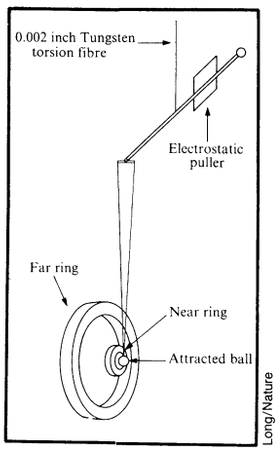




Ring and ball variant of Cavendish balance (left) determined slope (above) for variation of universal gravitational constant at short, but classical distances.

6.660×10^{-8} at 6 centimeters separation to slightly under 6.690×10^{-8} at 80 centimeters separation. (The unit of the constant is dynes times centimeters-squared per gram per gram.) The slope of the line, Long says, rests on 1,200 pages of calculations with 50 calculations per page.

Now, if the constant is not a constant, but a variable depending on the distance (at least at laboratory distances), then the law is no longer a simple inverse square relation but depends on the distance in a much more complicated way. What Long proposes in fact is to multiply the constant (that is, its usual generally accepted value) by a variable factor amounting to 1 plus 0.002 times the natural logarithm of the distance. That complicates the works.

The experiment itself compares the gravitational attraction between two rings of different sizes and compositions and a ball. The large ring contains 57,580.83 grams of brass and has an outside radius of 27.112 centimeters, an inside radius of 21.589 centimeters and a thickness of 7.633 centimeters. The small ring is made of 1,225.271 grams of pure tantalum; its outside radius is 4.5536 centimeters, its inside radius 2.7513 centimeters and its thickness 1.7765 centimeters. Rings were chosen for a convenient field configuration.

The ball to be attracted by these rings is 50 grams of tantalum. It is suspended from a counterbalanced rod. The rod in turn is suspended at its balance point by a tungsten wire. The gravitational forces on the hanging ball are measured by balancing them against an electrostatic force exerted on the opposite end of the rod. The large ring is placed farther from the ball than the small ring, and the quantity to be measured is the ratio of the difference between the torques exerted on the rod by the attractions of the two rings for the ball to the torque exerted by the attraction of the near one. The whole thing must be done in a vacuum and must be strictly shielded from vibrations and other disturbances.

In the same issue, NATURE carries a comment by one of the journal's anonymous scientist-correspondents. The commentator suggests that Long's result may be an indication of a small repulsive component to the law of gravity at these distances. Long says this may be the case, but the most important thing right now in his opinion is to get together the resources so that someone else can duplicate the experiment and see if the results are reproducible. Then one can see about alterations in the theory. □

Families and intellect: Scores to increase

If simplicity is beauty, then Robert B. Zajonc is to be congratulated for a beautiful piece of work. Last year he proposed an elegant, straightforward theory that helps explain individual differences in intelligence (SN: 2/8/75, p. 82). For this work he and Gregory B. Markus received the 1975 Socio-Psychological Prize of the American Association for the Advancement of Science. Now, with a growing body of data to support his work, Zajonc, a University of Michigan psychologist, uses his theory to explain the ongoing, 12-year decline in Scholastic Aptitude Test (SAT) scores. But a good theory does more than explain—it predicts. In the April 16 SCIENCE Zajonc predicts what might be a dramatic increase in SAT scores by 1980.

The theory, called the confluence model, relates intellectual growth to family configuration—family size and the age spacing of children. The basic idea of the model is that within the family, the intellectual growth of every member is dependent on that of all other members, and that the rate of this growth depends on the family configuration. This can be illustrated mathematically. Suppose the absolute intellectual levels of parents to be 30 arbitrary units each, and the intellectual level of their newborn child to be zero. The intellectual environment of the family at the birth of the first child, then, has an average value of 20 (30+30+0/3=20). If a second child is born when the intellectual level of the firstborn reaches four, the second born enters into an intellectual environment that has an average value of 16 (30+30+4+0/4=16). If a third child is born when the intellectual level of the first has reached seven and that of the second child is three, the family intellectual environment will be reduced to 14.

These figures suggest that intellectual environment should decline with birth order, but child spacing must also be considered. If the second child is not born until the first reached an intellectual age of 24, the newborn enters an environment of 21, which is even more favorable than the 20 entered by the first-born. Hence, says Zajonc, with large enough age gaps between children, the negative effects of birth order can be nulified or even reversed.

Zajonc admits that this sort of formulation is "obviously a simplification of what is an enormously complex process." The amount of time parents spend with their children as well as what they do during that time is important. A game of tag may not be as conducive to the development of intelligence as a game of chess. But even though the confluence model ignores much of the richness of the social processes that go into intellectual growth, it does help explain and predict differences in intellectual test performance. Zajonc cites several large-scale studies.

The average scores of nearly 800,000 candidates on the National Merit Scholarship Qualifications Test were examined as a function of family size and birth order. Scores declined with increasing family size and within each family they declined with birth order. Similar results come from other studies: 70,000 school children in Scotland, 100,000 in France and 400,000 in the Netherlands. Even though the results are from different tests, different age groups and different countries, they all indicate that intellectual level generally declines with family size. The rate o decline was not the same for all studies, but the confluence model can account for the differences by considering the birthrates and age spacing between children. As birthrate goes up, spacing declines and family intellectual environment declines.

Other evidence comes from twin studies. When twins are the first offspring, the family intellectual environment at birth is 15 (as opposed to 20 for a single child). This should and does show up on test results. The effect is heightened for triplets. For twins separated at birth (by the death of one or for some other reason), test scores are nearly the same as for nontwins.

Parental absence is another factor. A child born into a one-parent family enters an intellectual environment of 15. Test scores and studies of children of men in the service support this. Studies also show that remarriage by the remaining parent, if it occurs early enough in the child's life, results in improved intellectual performance. Only children present a special case because they don't score as high as would

be predicted by the theory. Zajonc believes a possible explanation may be that only children have few opportunities to act as teachers.

The confluence model also addresses the question of differences in intellectual test performance among different national, regional and ethnic groups. In 1960 white families in the United States had an average of 2.27 children. Black families averaged 3.05. The interval between children is longer in white families, and the average age of white mothers at the birth of their first child is three years older than for black mothers. The rate of father absenteeism among black families is about three times that of white families. "It would be surprising," says Zajonc, "if these differences in family configuration between whites and blacks were not seriously implicated in the differences sometimes found between these groups in intellectual test performance."

With all of the data conforming to the theory, Zajonc turned to SAT scores. After World War II, the dramatic increase in the birthrate changed the configuration of the average family. When children from these more crowded families began taking the SAT, scores began to go down. But the birthrate has since decreased and the number of children per family has gone down. If the theory holds, the SAT scores should begin to go back up within the next four to six years, according to Zajonc's projections. An increase in scholastic performance is already evident beginning with children born in 1962.

This theory, of course, is good for more than predicting general intelligence test performance. It has implications for family planning, education, population growth and the composition of day-care centers. But, Zajonc cautions, "IQ isn't everything. Large families may contribute to growth in attributes other than intelligence: social competence, moral responsibility or ego strength, for example."' □

Liquid membranes trap assorted poisons

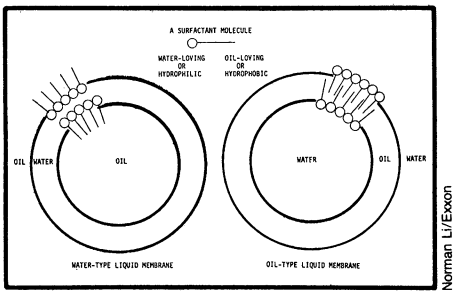
One man's chance discovery made 10 years ago may soon aid poisoning victims and drug addicts, help persons with kidney diseases and clean up polluted waste waters in Japan—among other things.

Chemist Norman N. Li of Exxon Research and Engineering Co., of Linden N.J., described his discovery of liquid membranes to the American Chemical Society meeting in New York last week. Several other researchers, developing promising new applications for liquid membranes, reported their latest progress.

Li was studying the nonmixing characteristics of oil and water in 1966, and investigating the way surfactants such as detergents affect the normal interface formation of the two components. He was doing a routine measurement when he noticed liquid membranes forming in his flask. Detailed study revealed that these membranes are composed either of oil or water and are "nailed in place," Li says, by the surfactants.

Surfactants are molecules with a hydrophilic or water-loving end and a hydrophobic or oil-loving end. Surfactants line up at the oil-water interface (oil-loving end toward the oil and water-loving end toward the water). This forms thin membranes, either water membranes that surround droplets of oil suspended in an oil medium or thin oil membranes that surround droplets of water in a water medium.

Li found that he could make spherical liquid membranes of either oil or water and surfactants by emulsifying the ingredients at high speed—the higher the mixing speed, the smaller the spherical membranes and contained droplets. He and co-workers also found that various solutions such as acids and bases can be contained in the droplets and will trap and remove unwanted molecules from the surrounding medium. He discovered, too, that additives can control the physical properties of the membranes: Certain additives make the membranes very sturdy. Others control the passage of molecules, allowing some to diffuse through the membranes but not others. And still other additives can control the rate of this diffusion.



Norman Li/Exxon

Poison eaters: Liquid membrane systems

"It is gratifying," says Li, who now owns 16 patents for liquid membrane systems, "to see the growth in basic research on liquid membranes and the many potential applications being studied all over the world."

Treatment of poisoning victims is one of the most promising of these applications. There are more than one million poisonings per year in the United States, and 10,000 poisoning victims die. One of four suicides involves a drug overdose (usually a barbiturate) and 70 percent of accidental poisonings occur among children, usually taking aspirin. Existing treatments, says Exxon chemist J.W. Frankenfeld, are unpleasant, antiquated and sometimes ineffective. He and University of Rhode Island pharmacists Christopher Rhodes and George C. Fuller are therefore developing alternative antidotes based on liquid membrane systems. A variety of solutions can be contained in oil membranes and will remove drugs, petroleum products and other poisons from surrounding media. The team tested both aspirin and phenobarbital and found that liquid membrane solutions will remove 95 percent of each drug within five minutes from acidic solutions (such as those found in the stomach). He envisions a series of dry ingredients, that could be stored on home or hospital shelves and mixed in a blender to treat emergency poisonings. Animal tests will begin soon and clinical trials are expected within two years, he says.

Drug addicts might be on the receiving end of another liquid membrane application. Multiple emulsions (oil in water in oil) containing the narcotic antagonist Naltrexone are being developed as "timed-release" drug systems for addicts. Naltrexone blocks the opiate "high," but must be injected too frequently for successful use in outpatient treatment centers. Research pharmacist Sylvan G. Frank from Ohio State University told the ACS division of Industrial and Engineering Chemistry that Naltrexone, when encapsulated in tiny liquid membranes and injected into muscle tissue, escapes slowly into the blood stream. Trials show that an intramuscular injection can sustain the antagonistic effect for two weeks, Frank says.

Another potential biomedical application is the treatment of chronic uremia (kidney insufficiency). W.J. Asher, also of Exxon's Linden, N.J., laboratories, is working on a liquid membrane system that could be ingested to cleanse the blood of toxic urea. This could reduce the number of times per week kidney patients must undergo painful, time-consuming dialysis, Asher says. In his experimental system, urea that has accumulated in the blood will pass through the mucosa of the small intestine to the lumen, where it can be trapped by liquid membranes moving through the gastrointestinal tract. The membrane system functions well in dog intestines, he says, but improvement of urea-trapping rates must be achieved before clinical trials can begin.

A very different application—removing heavy metal pollution from industrial waste water—is being explored in Japan. Toshio Kitagawa of Takuma Co., Ltd., Osaka, reported the intial success of a liquid membrane pilot plant in that city. Chromium, cadmium, ammonium, mercury and copper can be removed effectively, Kitagawa finds, and he expects to use the process in a full-sized plant soon.

Other applications, Norman Li says, include separation of organic compounds (such as the upgrading of petroleum products), extraction of metals from ore and oxygen-carbon dioxide exchange in an artificial lung. □