liquid drop model turned out to give too small a value. The deformed shell model, in which each of the nucleons moves independently, was found to give the rigid body value. This remarkable result was first discovered in another context by Niels Bohr, Aage Bohr's father and Nobel Laureate, in 1911. Neither the liquid drop model nor the independent particle model is correct. In fact, in order to obtain the experimental values it is necessary to take account of the residual forces between the nucleons, the precise values thus providing information on their nature.

These results are important for understanding not only nuclear structure but also the many body problem, the fundamental problem underlying all of modern physics. The nucleus provides a rich variety of phenomena. Their elucidation for these relatively small systems and for the moderately strong interactions that exist between the constituent nucleons will undoubtedly provide new insights into the characteristic quantal forms of motion which a many body system can undergo.

It is intended by this brief account to give some insight into the catalytic nature of Rainwater's contribution and the mighty edifice Bohr and Mottelson have built. I have concentrated on their early work. There have, of course, been many subsequent developments, both experimental and theoretical. Many fundamental problems remain unsolved. The reader is referred to the forthcoming second volume of Bohr and Mottelson's book, *Nuclear Structure*, for a complete discussion. And, of course, I must apologize to the many physicists whose significant contributions have not been mentioned. But with regard to the developments discussed above, Bohr, Mottelson, and Rainwater played a central and decisive role.

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Malodor Counteractants: The Nose No Longer Knows

The complex mechanism by which we perceive odors is still largely a mystery. It is generally accepted that the shape of a molecule is one of the most important factors in determining its aroma and that the molecule must interact with specific receptors in the nose to produce an effect, but the receptors have never been isolated and their nature can only be guessed. A little bit more may be learned about these receptors as the result of the serendipitous discovery of a new class of chemicals that inhibit the interaction of malodorous compounds with the receptors.

The chemicals, called malodor counteractants, were discovered about 7 years ago by Alfred A. Schleppnik of Monsanto Flavor/Essence Inc. of St. Louis. Little was done with them for the first few years after their discovery, however, since the effect they produced was so contrary to established theories of olfaction. Only about 2 years ago did officials at Monsanto begin to accept the fact that the phenomenon was real and initiate a vigorous research program to document the effect and to find commercial applications for the chemicals.

The majority of commonly encountered malodorous chemicals, Schleppnik says, are small molecules that can either accept or donate a proton. These include low-molecular-weight carboxylic acids (the primary offenders in perspiration and rancid foods), thiols, phenols, and amines (many of which produce fishy odors). How these molecules interact with receptors in the nose is still a matter of speculation, but there is much evidence to suggest that they all interact with just one type of receptor.

Conventional deodorizers and air fresheners act by flooding these receptors with a large number of molecules, creating a strong odor that masks the malodor. In the process, a much higher total odor level is produced. In contrast, very small quantities of the malodor counteractants appear to react with an allosteric site (a second site distant from the receptor) on the receptor molecule (which is presumed to be a protein) to produce a conformational change that blocks the receptor site. The net effect is that the olfactory nerves do not perceive the malodor, and there is an apparent lessening of the total odor level. The counteractants do, however, also interact slightly with trigeminus nerve receptors in the nose (which are thought to produce a warning in the form of stinging, burning, or tingling sensations) to produce what Schleppnik describes as a "fresh air" smell indicating that "something indefinable is there."

Others Are Similar

In one sense, the counteractants are not unlike other aroma chemicals. Many commonly used aroma chemicals can enhance or inhibit the awareness of an accompanying odor even though they have no aroma of their own. Perfumes often contain many such ingredients. The model of allosteric interaction proposed by Schleppnik provides one possible explanation for how these seemingly odorless ingredients can modify the aromas of the primary ingredients. The malodor counteractants, he adds, differ from these other modifiers only in the completeness of the inhibition and in the larger number of odors affected.

The identity of the counteractants has not yet been disclosed because Monsanto has not completed its patent applications. All of the many counteractants, however, are relatively simple compounds with masses from 150 to 250 daltons. All have, or can assume, the same three-dimensional shape, and all have similar distributions of electron density and polarity, even though they do not all contain the same functional groups. They are not ionic, they contain no aromatic rings, and they are not soluble in water. Their activity is highly stereospecific, but unresolved mixtures of stereoisomers can be used commercially to reduce costs. Some of the chemicals produce their own aromas (by interacting with a second receptor), while others do not. The counteractants are so simple, Schleppnik says, that the revelation of their identities will probably be "anticlimactic."

The counteractant effects persist for as long as concentration of at least 1 part per million is maintained in the air. When exposure to the chemicals is stopped, sensitivity to malodors returns within seconds; a concentration of a few parts per million will remain in a room for hours, though. A large number of tests—including his own extensive exposure, Schleppnik says—indicate that there are no residual effects associated with either prolonged exposure to the counteractants or exposure to abnormally large quantities of them. There are no government requirements for testing of

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such aroma chemicals, however.

Test marketing of consumer products containing the counteractants—which Monsanto now calls amals—has already begun, although the company will not reveal the identities of manufacturers using them or of products incorporating them. They are not, however, present in certain highly advertised deodorizers that make rather extravagant claims. The products are being promoted cautiously because of the many previous times that manufacturers have made similar claims without being able to deliver. In the words of a Monsanto official, the industry "has cried 'Wolf!' once too often." The counteractants have been or will soon be used in home air fresheners and such products as depilatories, shampoos, and cosmetics, all of which often contain essential malodorous ingredients.

Other potential uses might be in deodorant soaps, home "permanents," underarm deodorants, douches, and pet litter boxes. Additionally, other work at Monsanto suggests that the counteractants could be incorporated into many industrial products in an encapsulated, slow-release form. Many kinds of box board, plastic tiles, paper, and other products, for example, produce odors that are not harmful, but that are offensive to potential purchasers of the products. Incorporation of the counteractants could overcome this problem.

Academic scientists have been reserved and skeptical about Schleppnik's claims, in large part because he has not been able to supply them with samples of the counteractants until Monsanto is protected by patents. But those who have smelled for themselves believe the phenomenon is real, regardless of whether Schleppnik's explanation of it is or is not correct. Some of the scientists, furthermore, suggest that the counteractants could be valuable for studying olfaction.

At present, the perception of odors can be blocked only with rather crude reagents that irreversibly alter receptors or the nerves connecting them to the brain. Because the effects of the counteractants are reversible, they should make it possible to conduct much more sophisticated experiments with the receptors. The counteractants might also be useful in the study of insect chemoreceptor systems and of proton transfer enzyme systems. But their value for such applications cannot be fully assessed until they are made available to more investigators.

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