into the development of new fragrance raw materials, continued development of consumer test methods to keep abreast of the changing trends, and closer working relationships between the perfume houses and finished goods companies. Our program today should provide some interesting insights into these areas.

Dr. Ira D. Hill is a corporate vice president and the director of research and development of International Flavors & Fragrances Inc. He received his BS degree in chemistry from Abilene Christian College in 1956; his MS in chemistry from Purdue University in 1958; and his PhD in biochemistry from the University of Texas in 1962. Dr. Hill has lectured extensively in the United States as well as abroad, and has authored many publications in microbiology, fermentation, and toxicology. He has participated in a number of governmental hearings including those of the Food and Drug Administration, Environmental Protection Agency, House Public Works Committee, and the Senate Commerce Subcommittee on the Environment. Dr. Hill is a member of the American Society for Microbiology and the American Chemical Society. He served as chairman for the Division of Microbial Chemistry and Technology of the American Chemical Society and, is a past chairman of the Bio-Medical Research Committee of the Soap and Detergent Association.

Inter-Disciplinary Organoleptic Research

Dr. Ira D. Hill, International Flavors & Fragrances Inc.

Natural product analysis and multi-step organic synthesis have been the twin pillars of aroma chemical research for the last 75 years. Their importance in research, by our company and by our colleagues in other companies, is clearly evident by the continual flow of papers in the scientific literature and by the new chemicals which you use so creatively.

However, for this discussion, I'd like to relax the pursuit of data and interpretation and discuss instead research philosophy. Since my responsibility is to direct research for both fragrances and flavors I must discuss both, even though I recognize that the majority of this audience is primarily interested in fragrance.

I'd like to begin with two postulates. The first one is that problems are solved rapidly not by putting ten scientists of the same discipline and training on a task, but by putting ten different scientists of three or four different disciplines on the same task. Now that concept doesn't always make me the most popular fellow among the organic synthesis chemists, because if you ask a good organic chemist what he needs to turn out twice as many good smelling aroma chemicals, he will reply "Twice as many chemists." But my postulate is to put together multidisciplinary teams even to attack that which appears to be a straightforward synthesis or analytical problem.

The second postulate is that flavor and fragrance are overlapping considerations of a single question, and they must be researched together.

Now perhaps you would disagree with the absoluteness of those postulates, but that's my starting point. I think the reason for these postulates will become clear as we proceed.

Many of you have honored us with a visit to our research facilities in Union Beach, New Jersey. But you know, no matter how impressive any company's facilities are, what is important is what comes out. Like the business of creating perfumes: beautiful bottles are important to the overall image, but you just can't substitute for the quality of creative thought that puts together what goes into that bottle. All the fancy gas chromatographs in the world may make a nice tour, but they don't make research. I'd like to describe to you how we build a research program.

In our program, we completely surround the organization with research perfumers and research flavorists. At no time in the pursuit of our research are the perfumers or flavorists more than minutes, literally minutes, away from consultation in smelling and tasting with our chemists and other scientists. At IFF, research perfumers and flavorists are sort of a special breed. They must be able to think like chemists, but be comfortable with the manipulation of scientific equipment, and they must be able to converse easily in the same technical language as the scientists. Perhaps the latter is a bigger stumbling block than sometimes we realize. I always thought I was able to communicate pretty well until I had my first introduction into this

The Organizing Committee of the 23rd Annual Symposium of the Society includes (front, from left) Kathleen Brown, Saul Klabin, Louis Schmitt, Theodore Barba, (back, from left) James Bell, John Porter (Chairman), Louis Coenen, Robert Gaudelli, Joseph Palmeri, and William Doughty.

business less than three years ago, and I found I had a totally new language to learn.

There is a language problem that exists between the interaction of perfumers and chemists. Research perfumers help us with the language problem. They must also, of course, be creative, but we usually distinguish research perfumers from our other perfumers. And the difference is that the research perfumers do not spend 100% of their time attempting to create fragrances for final use in perfumes such as would be sold for toiletries or soaps or detergents. Instead, the research perfumers develop a different kind of expertise and a unique sort of creativity. And that is the ability to perceive the creative utility of a new molecule or a new mixture of molecules long before it's purified and polished to a state that would be useful to the final product perfumer.

They must, of course, be able to follow that development of the new molecule through and into its very first creative utilization. Obviously, they begin their interaction with the base of our research organization: research on analytical techniques. We spend a rather large percentage of our total research money on the continual development and redevelopment of these basic tools.

Gas chromatography is of course the most widely practiced technique, I think, throughout the industry. However, the development of glass capillary columns seemed especially suited to the study of flavor and fragrance molecules; several years ago, we began our own research to explore this new technique and adapt it for our own needs. This has been an extremely successful program, and we are now manufacturing in our own laboratories four hundred foot capillary glass columns which have the resolution ability of up to one million theoretical plates.

These are routinely used in conjunction with our mass spectrographic program.

The combination of these two powerful tools leads to a new problem: too much data. I never thought that I, as a research director, would ever say that, but it's a simple fact, there is just too much data. Sorting it out correctly requires still another group of scientists, computer experts, and on and on it goes. Sometimes I think scientists really exist only to breed other scientists. Every time one of them finds something new, he's got to have a buddy to help him interpret it. I'm sure perfumers don't suffer from that syndrome.

The main thrust of our nuclear magnetic resonance program has been to continually reduce the size of the required sample and to speed up our ability to perform what's called Fourier transformation of the data. We're currently operating routinely with sample sizes of ten micrograms and achieving better quality NMR spectra than a few years ago when the minimal sample size was 100 micrograms.

The point thus far is that to build a base for technology, you've got to start all the way down at the bottom level, in this case, analytical techniques that may not initially seem to have any direct relationship to fragrance chemistry.

High pressure liquid chromatography, another part of the analytical program, has been a useful tool for some years, particularly in the study of molecules important to flavor, but which were not extremely volatile. Lately, we've re-emphasized our basic studies into this technique because of our belief that much of what we perceive as fragrance is affected by molecules which in and of themselves have little or no aroma. In fact, they may not even be volatile in the classic sense of the word.

Our most recent analytical program is the use of radio isotopes. The laboratory for this program was not even built until the last year. However, the use of radio isotopes as an analytical technique allows us to approach, and in some cases, exceed the sensitivity of the trained nose to detect aroma or flavor molecules. There is, of course, a limitation to the radio isotope technique. Those noncreative machines can only indicate the presence of the molecule, not whether it smells good or not. No matter how sharp our chemists get with their radio isotope technique, they are certainly no threat to job security for either flavorists or perfumers. Sometimes when our scientists get too big for their britches, I have to remind them that all they can do is tell me if it's there or not. It takes another discipline to tell me whether it's worth anything from a creative standpoint.

We're also laying a base in another area which we call physical organic chemistry. Now perhaps this is not a good title for that program, but it's the best one I've been able to come up with. Primarily it's an attempt to answer the question, "How do flavor and fragrance molecules react with their immediate environment, and how does that affect our perception of them?"

Classically, reaction mechanisms have been used to study organic synthesis, and naturally, our organic synthesis people are concerned with the mechanistic implications of the reactions they are studying. However, in a more basic sense, we will look at reaction mechanisms as a way of explaining why either natural products or synthetic products often lose their characteristic lovely odor or good taste before any analytically detectable changes occur. We feel that our understanding of the very initiation of changes to organoleptic molecules will provide us with unique guidance of how to make commercially acceptable and really useful products. Perhaps it will even help us to reduce the cost of producing such materials.

Natural product research is still an important part of our research effort. I will not dwell on this program except to say that the continuing restudy of the analytical techniques and the physical organic chemistry beneath it means that about every four or five years we must re-research the natural products we felt we had completed before. Perhaps the best example of this in our own shop right now is Attar of Rose. In 1970, we initiated a research program on Attar of Rose and at that time increased our knowledge of the contents of that lovely material from about 90% of its content, to where we felt we knew what 99%, or perhaps 99½%, of the material was. At the end of that program, we had exhausted our analytical techniques and laid the subject of Attar of Rose aside. Unfortunately, even with a knowledge of greater than 99% of the content, the magic of that material was such that we were unable to create a synthetic Attar of Rose of the highest quality. We were able to

Members of the 1976-77 Executive Committee of the Society are (from left) John Porter, Thomas Lombardi (President), Robert Gaudelli (President-elect), Simone Fedak, Lawrence Janosky (Secretary), Theodore Barba (Treasurer), Emil Buongiorno (Vice President), and William Doughty.

make several rose-like compounds, just as many of our colleagues have been able to do, for use in soaps and detergents. By 1976, we felt we had made enough progress in our basic knowledge of analytical techniques and also considerable progress in this interdisciplinary research that I'm describing, where the research perfumers work hand-in-glove with the analytical chemists, that we began a reinvestigation of the subject. We don't expect to complete this phase of Attar of Rose research until the latter part of the year. However, we're already beginning to see some very exciting results.

More and more of our effort at this level is being directed toward answering questions about such subjects as substantivity or diffusivity. We feel that this is the heart of why fragrances really work.

For example, if the detergent perfume is to do its job, it must not only smell pleasant in the detergent box and in the washing machine, but should also impart to the fabric a sense of cleanliness and pleasantness and freshness. To approach this kind of problem from a scientific point of view, although creatively many of you have been doing it for a long time, we must have input from all kinds of disciplines including radio isotopes, gas chromatography, high pressure liquid chromatography, and especially physical organic chemistry. All are completely intermingled with the continuing observation and guidance, and sometimes argument, from the research perfumers.

The same question is applied to the interaction between flavor molecules and proteins. With the increasing interest in nonclassical sources of protein for nutrition, such as soy bean isolates or a single cell protein, it becomes particularly important that we search for those flavor molecules which can interact with the protein much the same way that they interact with the protein of beef or fish which has historically been man's source of nutrition.

The same question should be asked about another word perfumers use: "diffusive." What makes a molecule diffusive other than its vapor pressure? Obviously, it's not just vapor pressure because if one ranked molecules in order of their measured vapor pressure and then asked perfumers to rank them in order of their diffusiveness, you won't wind up with the same order. We're beginning to learn some very exciting things about this subject at molecular levels far below that which can classically be obtained with vapor pressure experiments. Here again, radio isotopic techniques combined with gas chromatography are useful for determining the presence of molecules in very low quantities such as one might expect to be present on the skin several hours after application of a cologne.

Food chemistry is also a part of our research program. Perhaps that subject is not as much of interest, but I think it does point up the way we're mixing all of these disciplines. It used to be that flavorists were quite satisfied if they could put the flavor into a gravy, soup, sauce, or beverage and pour that over whatever food was to be consumed; just drink it. It is obvious, I think, that this approach to alleviating world food problems is not sufficiently sophisticated.

In order for the flavor to truly do its job, that is, give pleasure to the consumer and encourage the habits of better nutrition and the eating of more balanced diets, we must not only understand the chemistry of the flavor, but we must understand the chemistry of the food system into which the flavor is to be placed. Perception of a flavor is strongly affected by the chemistry of the food material into which it is placed, just as the perception of a fragrance is a function of its environment whether it's skin or soap or just the air.

All of the basic research so far described must finally lead to practical utilizable materials. I tend to get a little impatient with those basic activities because I've got the boss always on my back saying, "Where are the goodies, where are the goodies?" And if it's not the boss, it's the perfumers.

Finally at this level, we begin to see something coming out. The major portion of our effort is, as you would expect, in the area of chemical synthesis. However, we do not allow our chemists to grow fat and complacent with their chemistry. Just as we found that natural product research is greatly stimulated by the presence of scientists who are asking questions regarding the chemistry of food from which a flavor is being extracted, or physicists who are interested in the questions of why a molecule is bound to a fabric in a certain manner, we find that introduction of research on biological processes provides

a great stimulus for our synthetic chemists. In fact, at the risk of offending one or two chemists, I have to say that I have never seen chemists scramble quite so quickly to make an impossible-to-make molecule than when a good microbiologist lets one of the microbes out of its cage, and makes a few milligrams to show to a chemist. The next day a whole vial of little white crystals appears on my desk, courtesy of the chemist. So there is a real interaction that occurs by putting these mixed disciplines together.

For many years now, IFF has been commercially successful in producing truly natural flavors by biological means. We use the word natural in the context of the legal understanding of a natural flavor, that is, it must originate with food grade raw materials such as casein from milk or vegetable fat or starch, etc., and the biological processes must be those which have historically been used in foods such as microbial processes for cheese or enzyme processes for carbohydrate alteration. When these are combined with practical cooking or extraction or distilling techniques, some very intense and very natural flavors develop. The success of this program was so great that we've also begun a program to study the use of biological processes for the production of fragrance materials.

Really, the idea of using biological processes to make fragrance materials is not very revolutionary. A lot of other people besides us have thought about it and written about it. In fact that is the way nature does it. All of the materials which smell so beautiful in the fully opened blossom of a rose were there in precursor form in the tightly closed rosebud. The combination of sunlight, plant enzymes, and their resulting energy processes caused these precursors to develop into the lovely complex fragrance of the rose.

I would like pay a tribute to a wonderful friend and perfumer who is gone now, Mr. Ernest Shiftan. He raised this concept on my very first day at IFF and, to use today's language, he really raised by consciousness on the subject. My first introduction to the wonderful mystery of fragrance was his question, "Can we do what nature does?" So if we are successful in this program, a tremendous amount of the credit will go to that germ of an idea that was planted by Mr. Shiftan nearly three years ago.

At this point in our research program, we insert a barrier. The barrier is the discipline of toxicology. Before any product is moved forward into further development or even before it is available to other departments outside of research, the material must pass the examination of our toxicology group. The requirements for this discipline are growing dramatically. That's no news to anybody here. In 1976, we increased our toxicology effort three times. This year we have increased our involvement in toxicology by another factor of three. About two more of those threefold increases and it's going to be bigger than our whole cotton pickin' research organization. I hope to put a stop to that shortly, but it certainly is evidence of what this kind of effort imposes in terms of great financial restriction upon our research.

Even though this barrier means that many materials with lovely smells or the potential for helping us to create excellent flavors never leave the research center, I personally believe this is a socially justifiable expense. We must continue to discipline ourselves to seriously consider the toxicity of any material which we might use whether it is created by classical chemical synthesis or by a biological process.

One outgrowth of this research philosophy is a metamorphosis of my scientific vocabulary. I no longer talk about inventing and researching. Instead, I say create even for our chemists, because in their own right, not in the same way as perfumers, they are very creative.

If we've been successful, the sum of all these programs will give us a reasonable number of processes which are ready for development. We do not isolate our engineers from the multidisciplinary approach either. Our director of process development, Dr. Taylor, is, in his own personal research discipline, a synthetic chemist and is required not only to uphold the standards of rigorous chemical engineering but also to assure that the process development team understands the chemistry of the reaction. Sometimes our chemists think the engineers don't understand chemistry; and sometimes our engineers think the chemists don't understand engineering; but by knocking heads a few times, we tend to understand each other.

Even the process development engineer continually interacts with the perfumers and the flavorists. Frequently we find that while the chemistry of large scale processes appear to be identical, there is sufficient difference in its odor or flavor to make the process unusable. Now this doesn't make the chemists very happy, and after I've had to spend the money to bring it all the way from the bottom up to that level, it doesn't make me very happy. But that's the breaks of the game.

I have described our research program in only the broadest sort of an overview. I thought perhaps you might also like an idea of the balance of effort between people and research expenses within this multidisciplinary program. To do that I am going to let you see behind the scenes just a little.

At first there was some question in our corporation of whether I was revealing too many secrets. That is easily enough countered. The figures I am going to give are essentially from 1976 and already, given the nature of inter-disciplinary research, are not the same anymore. Some very old secrets will nonetheless give some feeling of the balance of effort.

A little less than 20% of our manpower is expended on the development of our basic techniques. Now probably greater than 20% of our total technology dollars are spent in the area of method development because of the extremely high cost of instrumentation. Approximately the same amount of effort goes into the area of natural product research and the utilizable aspects of our physical chemistry and reaction mechanisms.

Sometimes it's difficult to tell just where one of these functions begins and another one ends because many of our natural product researchers make substantial contributions to the development of the basic technology, and many of our analytical and physical chemists are actually involved in the practical aspects of utilizing their techniques in natural product research.

As you might expect, a larger percentage of the program is devoted to the synthetic or biological process levels. Perhaps you would be interested to know that the new disciplines are the most rapidly growing of our scientific disciplines. We do expect to see these efforts grow at a faster rate than the traditional research line which has been the mainstay of flavor and fragrance research.

The percentage associated with toxicology is rather small, but also a little misleading. Much of our total toxicology budget is spent for the services of testing laboratories in several locations throughout the United States and Europe to physically perform the tasks which we design and interpret.

The largest area of effort is in the process development. This is in part due to the necessity of operating the pilot plant on a round-the-clock basis. It also reflects the increasing pressure due to new materials. Perhaps a good example of this pressure is for the development of intensely odored molecules for flavors or to contribute strong notes such as ambergris notes in fragrances. The more we study natural products, the more we find very strongly odored materials. These ingredients, which are very precious, are at very low concentration in the natural products, sometimes present at less than ten parts per million. If they are made synthetically, they must be made in concentrated form. And therein lies the problem. The old standards of chemical engineering are just not adequate for the development and control of very intense organoleptic materials. We have spent a considerable amount of our process development energies in developing new techniques for study and control of processes, control in the sense of controlling odor and its pollution potential.

Many areas in our pilot plant now resemble those found in drug companies producing hormones or other materials which in their concentrated states are highly toxic. We are not concerned so much about the toxicity of these materials as about their impact upon the organoleptic sensation, both on the part of the workers and on the part of the environment around our research operation.

Surely it is obvious that we do not do research primarily for the pleasure of it, although we take great pleasure in the research we're allowed to do. And I might say, that being an absolute novice in this field, I've never had so much fun in my life! For a scientist, there is no greater pleasure than this kind of high technology coupled with products that can be either smelled or tasted when you're finished. But the boss doesn't like to hear me talk too much about the pleasure of doing research; he wants to see the money coming out at the end of the pipeline. Our purpose really is to create materials useful to our perfumers and flavorists as well as to our competitors from whom we buy and to whom we sell. Therefore, we cannot stop our discussion of interdisciplinary research with that which just applies to the central high technology portion. We have to see how this interlocks with the total creative and technical structure.

At many locations around the world, we have applied laboratories which take the technology developed in our Union Beach facility and apply it to the specific consumer products of their locality. We frequently export to our affiliated laboratories not only the technology but sometimes the people and the machines so that they can apply the technology we have learned directly to solving problems such as a soy sauce flavor from Japan or the shortage or poor quality of a key natural ingredient for a fine perfume in Paris.

We consider the creative perfumers and flavorists to also be a part of the family of interdisciplinary scientists at IFF. After all, their ultimate purpose is the same: to find those raw materials arising from our basic technology which can be combined into products which excite the imagination, which give pleasure to those that use them, or which help alleviate world food shortages. Literally every day, several of our chemists or physicists or research perfumers or toxicologists are actively involved in the laboratory effort of the creative flavorist or creative perfumer.

Now back to the point about the flavors and the fragrances being studied together. Would you be surprised if I told you that the material which the creative perfumers at IFF found most exciting during 1975 and 1976 came not from a research program designed to find perfumery ingredients but rather from the flavor field? The tables were turned in late 1976 when perhaps the most exciting new chemical in the area of tobacco flavor turned out to be an old friend from our research in perfumes. At the same time, the basic approach to the creation of flavors which are stable under modern processing conditions, which is primarily a study in physical chemistry, originally began as a study in fragrance material.

Process engineering and analytical control of those processes are the final areas of technology to be discussed. Much of the technology for these two areas comes from the areas already discussed. In fact in many cases, a technique will go from basic analytical techniques and jump immediately into the process engineering area. I might also add that there's been more than one new research project introduced into the research program as the result of the insight of a process engineer who brought his particular discipline to bear on a problem which our synthetic chemists thought was completely resolved, and for which, in fact, the question was not even in existence.

A great many of our initial research interests come from our perfumers. Excellent chemists and really creative perfumers share a very common essence, which is curiosity. By allowing this curiosity to work between flavorists and perfumers and chemists and physicists and microbiologists, we feel that we can support the second postulate, that one really should consider flavors and fragrances to be the same question of organoleptic sensation.

Perhaps the best way to indicate the size of this effort is in terms of its total cost. And again this is no secret; you can read it in the annual report. In 1977, IFF expects to spend about $20 million on technology.

I continually remind our scientists who sometimes grow excessively proud of their scientific abilities that until the results of their research actually make contributions to the happiness and welfare of the consumer, their research is not truly fulfilled. I'm sure you will pardon me if I say that my pleasure in discussing our research philosophy will truly be made complete when we are able to share the results of that research in a very tangible form: materials which can be smelled and tasted and used by all of the peoples of the world.

Mr. Porter

Everett H. Johnson attended Dartmouth College and received his BS degree in science from Iowa State University. He was associated with Wilson & Company Sporting Goods and entered the fragrance industry in 1956 when he joined Polak's Frutal Works in a sales capacity. In 1961 he joined Fritzsche-Dodge & Olcott Inc., and in 1967 was assigned to the position of vice president of fragrance sales. He joined the Givaudan Corporation in 1973 in his present capacity as vice president and general manager of the fragrance division.

Bloom, Groom or Doom—Market Research Study of the Men's Fragrance Market

Everett Johnson, Givaudan, Inc.

The year is 1977; the place, New York City.

The American perfumers, creators of fragrances, are gathered for their 23rd annual summit conference. There is an apparent problem with the direction of the men's fragrance market. 1977 should be different from 1967 and 1957—and, hopefully, from 1987. But will it be? Will it be business as usual this year, or will someone plant seeds of doubt, question the usual, suggest the non or un-usual? Will someone seek out the new trends as well as dusting off the old patterns? Will someone, perhaps, see where we have been? Where we are? And, where we are going?

Assume it's the mid-1950s, and the men's fragrance marketing band is playing "We've Only Just Begun."

There was a tendency to spend money on grooming products for hair and hair removal such as shaving cream, razor blades, grooms, tonics, and aftershaves. A sign of market explosion in this era was the development of gift sets—a talc, cologne, and aftershave—all under one pretty roof.

"The industry is being rewarded with a bright expectation of large volume ahead." *Beauty Fashion* May 1955.

It's the 1960s. The same band is playing the same song with more experienced marketing choreography.

"We like the idea of the new product put out by the Old Spice Line, called Outdoor Lotion. . . . It opens a new specialized market among men such as surveyors, construction engineers, builders, farmers." *Beauty Fashion* Nov. 1961.

"An expanding market for direct purchase of fragrance by men is everywhere evident. It is no more a sign of masculinity to disdain the personal use of fragrance. . . . The men's toiletries market is bound to be among the largest growth areas in the industry." *Beauty Fashion* Nov. 1964.

"Observers of the market feel that the entire men's field is shaking down to a serious, sustained and steady kind of growth pattern. There is increasing effort to capture the mature audience as well as to educate the younger men to use toiletries. . . . The widening variety of men's products and the growth of drug store sales both reflect the same trend—a tendency for men to buy more of their grooming aids for themselves, no longer always waiting for their wives and the gift route." *Beauty Fashion* Apr. 1969.

It's the 1970s, and here we go again.

"Men will no longer face the world without cologne. . . ." *Beauty Fashion* Apr. 1971.

"The men's market is very good. It is really interesting how it has taken off by leaps and bounds." *Beauty Fashion* Aug. 1976.

It's 1977 and would you believe we're *still* looking forward to a prosperous and profitable fragrance future? Does "good press" necessarily mean that that's the way it will be? Doesn't anyone ever say they doubt future booms? Is it bad press to give bad press to the future before it's had a chance to happen? While it's still today? Is it putting, as the sayings go, the chicken before the egg, the cart before the horse? Is it something everyone will keep talking about without actually probing the problem, without actually *doing* anything about it? Have we "come a long way, baby," or is it really just "The Way We Were"?

As a matter of fact, how *were* we? How real is this repeatedly intermittent men's fragrance "boom"? How many more marketing bandwagons will there be to hop upon?

Let's take a look at some trends and hope they