

Physicists in industry

A physicist well matched to his job can expect rewards and satisfaction from an industrial career that are not always available in academic life.

Donald L. Hammond

My aim here is to state positively that in going into industry a physicist has every opportunity for a rewarding, satisfying and successful career. The match between him and industry will depend both on his training and on the kind of person he is, and I will accordingly have something to say about the curriculum for physicists, both in physics areas and related fields, and about desirable personality traits for a physicist in industry. In addition I will discuss the responsibilities of industry to the physicist and comment briefly on the future prospects for the job market, where I see a probable steady, though small, increase in the number of positions that will become available.

While preparing this article I took the opportunity to talk with a number of my colleagues at Hewlett-Packard and my counterparts in several other companies. It is not my intention to present their opinions here as a consensus, but I will occasionally refer to a general agreement among us where it exists.

It might be well to start with the questions: "What sets the physicist apart?" "What distinguishes the physicist from other professionals?" "Why, for example, would you choose a physicist for a particular assignment rather than an engineer?" Generally the answer to all these questions is that it is a matter of his approach. Typically, the engineer wants to start with a well defined objective, using technology that exists and is well established. These ingredients he rapidly assimilates to achieve an end product. By contrast, the physicist generally looks at many ways of achieving the end goal. Some of these approaches may require technology that

does not exist. Generally the physicist is expected to be more innovative and to bring to the team a broader background. Development programs carried out by physicists generally take longer, cost more and have higher risk, but when successful, result in a larger proprietary edge.

Curriculum and thesis

None of the research directors I spoke to are dissatisfied with the physics curriculum. Perhaps that is because the present curriculum is the definition of the physicist. This observation is important because it implies that we should not look to changes in the subject matter of the curriculum as the primary solution in providing better training for physicists in industry.

I encountered a mild concern for the distribution of emphasis. It was felt that "fundamental" or "classical" courses, such as mechanics, optics, acoustics and electronics, receive an emphasis not quite equal to that of the more sophisticated courses.

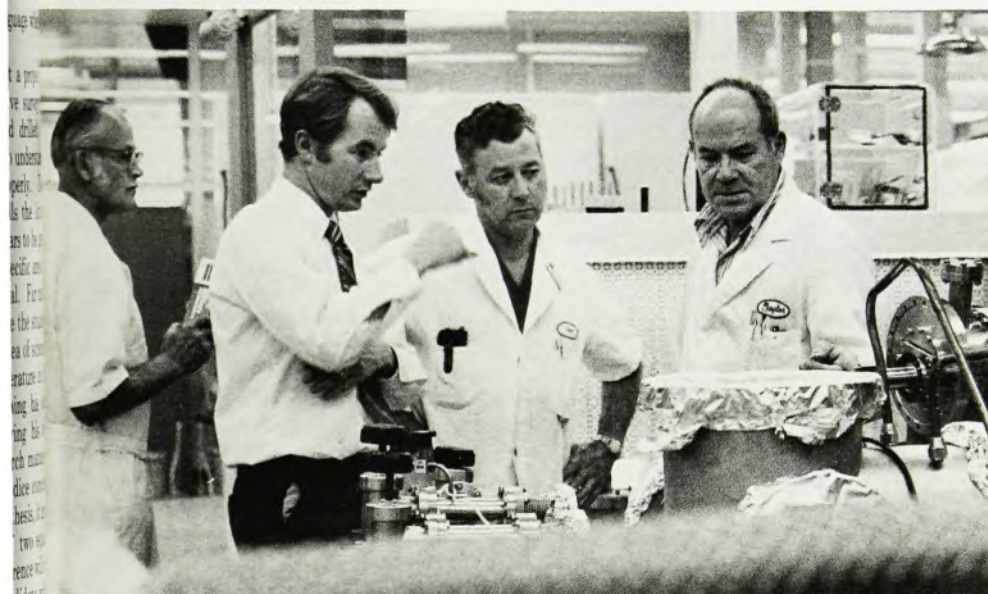
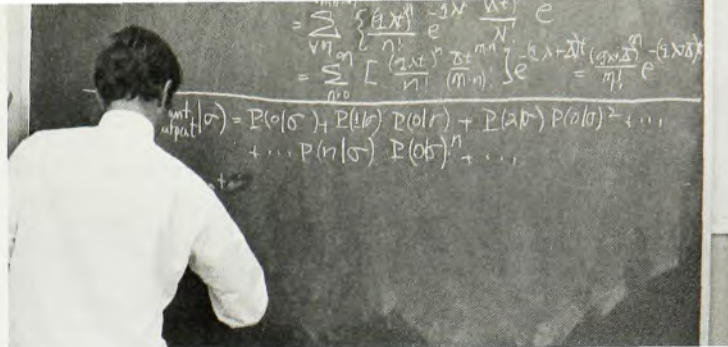
The physicist in industry, as in the university, has a need for rigor and the ability to carry out a thorough theoretical analysis of a wide range of problems. (It is important, however, to distinguish between the ability to replicate the analysis of the professor and the ability to analyze with rigor, judgment and perspective a problem in a totally new field.) In addition to needing this Einsteinian grasp of the field of physics, we in industry would like to see a broadly trained individual. We feel that recent trends toward increasing the number of electives is helpful. However, I suggest strong counseling to encourage physicists to supplement their physics with courses in biology, chemistry, computer science and other adjacent sciences. I would not disagree with substitution

of Fortran for a foreign language where two languages are required.

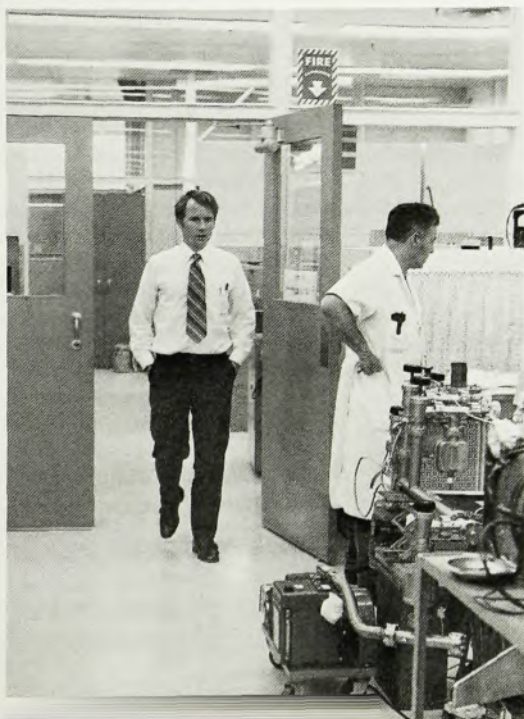
I have heard it said that a properly trained physicist must have surveyed the terrain of physics and drilled at least one hole to bedrock to understand the world of physics properly. The doctoral thesis properly fills the latter requirements. There appears to be general agreement that the specific area of thesis research is not critical. Far more important is the experience the student gains in grasping a new area of science, becoming aware of the literature in his field of research, developing his own instrumentation and solving his own problem. Although research managers readily disclaim any prejudice concerning the subject area of the thesis, it must be evident to all that of two equally qualified applicants, preference will certainly be given to the candidate with a thesis subject that matches his first assignment.

I found consistent concern for theses in the field of high-energy physics, a concern that I suspect has been adequately expressed during the past several years. When the student is a member of a large committee and not planning his own individual program, when he is using a many-megadollar accelerator and not preparing and organizing his own instrumentation, and when his mathematical analysis and physical concepts are not applicable in areas outside high-energy physics, this type of thesis provides less than optimum training for the physicist entering industry. High-energy physics is a very important area of basic research and appropriate for the subject of a thesis. However, students following this avenue should have no illusions that it is an optimum preparation for industrial employment.

More valuable than drilling one deep



Chuck Tyler is manager of the electron-optics group in the physical-electronics laboratory of the Hewlett-Packard research labs in Palo Alto. He has been with Hewlett-Packard for about two and a half years, and enjoys working in industry: "The pace and emphasis on accomplishment are two to three times what I found in the academic area." Here we show him working and relaxing during a typical day; the equipment in the photos at the left and lower left is a partially dismantled ESCA spectrometer. (Photos by Hal Smith.)



Some statistics

How many physicists do take up employment in industry? Statistics are gathered annually by AIP's Manpower Statistics Section, for all new graduates (bachelors, masters and PhD's). "In the past," Susanne Ellis of the Manpower Division told us, "industry has taken between 15 and 20% of the new PhD's each year. For the most recent graduating class, however, the fraction has dropped to 11%."

We present here the work-activity breakdown for bachelors and PhD's who graduated between July 1970 and June 1971. The bachelor-degree data are based on accepted positions for those who were interested in employment (that is, not counting those who entered graduate school or military service). The PhD data are for 737 individuals who reported their employment by the end of 1971, out of the 1530 new physics doctorates.

"The economy has not yet made room for the new PhD's," added Mrs Ellis. "As the table shows, half of the PhD's are engaged in research at universities. Most of them are temporary postdoctoral fellows."

New bachelor-degree graduates, July 1970-June 1971

Type of employer	Work activity										Total N	%
	Teaching			R&D	Engin- eering	Unskilled, supervisory and non- supervisory	Computer programmer	Management training	Other			
	Physics	Math	Other science									
Industry (technical)			2	33	86	48	33	15	5	222	30	
Manufacturer or service in- dustry (nontech.)				18	5	84	17			124	16	
High School	79	29	25		2	1			6	152	20	
College or University	9	3		29	2	3	4	1	6	57	8	
Government	1	4		33	11	4	13		20	86	11	
Peace Corps	16	1	1						2	20	3	
Other (includes self-employed)	3	2	1	13	9	15	8	5	35	91	11	
Total N	108	39	39	126	115	155	75	21	74	752		
%	14	5	5	17	15	21	10	3	10		100	

New PhD's, July 1970-June 1971

Type of employer	Work activity							Total N	%
	Teaching	Research	Teaching and research	Development and design	Management, administration	Not physics related	Other		
University	21	259	70	1		5	4	360	49
Four-year college	82	2	16					100	13
High school	18				1			19	3
Industry (technical)	3	22	1	42	8	5	4	85	11
Government	1	79	1	27	1	2	5	116	16
Nonprofit organization		10	1			1	2	14	2
Other	12	5	1	6	1	9	9	43	6
Total: N	137	377	90	76	11	22	24	737	
%	19	51	12	10	2	3	3		100

well is drilling two deep ones. It is characteristic of physicists that they like to continue drilling the same well for thirty years. This is seldom possible in industry. One of the expectations that industry has for physicists is the ability to move from subject area to subject area. We value the physicist's flexibility and his mental agility in moving from one problem area to another. It is important that the young industrial physicist make the first adaptation while he is still mentally agile and before mental rigidity sets in. Once this first hurdle has been won, it is relatively easy for him to move on to new fields and, with confidence, conquer them with equal capability. A second thesis in a different subject area might be of considerable value to convincing the young physicist while he is still at the university that he can succeed in more than one area of research and, at the same time, avoid over-specialization.

Character

One of the things industry is looking for is self-confidence and the associated traits of optimism, tenacity and perseverance. The physicist must often sustain himself through long periods of slow progress. The time constant required of a physicist may be as long as one to three years. A good deal of self-motivation and self-direction is required. The physicist must be willing to champion his own ideas . . . sometimes in the face of skepticism or disinterest.

To some extent self-confidence and its allied traits can be developed in the successful execution of a carefully chosen thesis that provides the deep satisfaction of accomplishment. However, to the extent that these traits are intrinsic, it is important that the university understand industry's needs and consider them in the selection of graduate students. The university is, in a very real sense, a preselection filter for industry.

On the other hand, his self-confidence should not turn into conceit. Occasionally a physicist arrives on the industrial scene feeling that he is far superior to the engineer, the technician, the manager and the marketing people. His ability to interact is then seriously impaired. I have known professors with a well developed ability to deflate a student's exaggerated ego, while willing and ready to help in building his self-confidence. This excellent discretionary involvement should not become a lost art.

I believe that physics has made a transition during the past two generations; it is no longer an occupation carried out in an ivory tower by non-gregarious people willing to forego potentially large financial reward to gratify their basic love for physics. To-

day, the physicist is expected to be much broader. His training is broader and his image in society has shifted from that of a monastic recluse to that of an energetic intellectual not at all averse to the rewards of success. The vocation of physics is being sought after by young people who want to go places both financially and socially. These additional motivations are fine, and we are all glad to see physicists gaining their proper social acceptance and a more equitable financial reward. But the aspiration for success cannot replace the love for physics as the basic motivation for physicists. The professor's contagious and unbounded enthusiasm for physics is a far more valuable stimulant than are the bulletins describing starting salaries for physicists.

Ability to communicate

Another important facet of this gem we seek is the ability to communicate. I agree with the generalization quoted by Susanne D. Ellis, in her AIP study¹ in 1969, on the match between academic training and employment of physicists. "Most highly trained scientists have trouble communicating." This may be partially attributed to a strong correlation between a shy and retiring personality and the choice of a scientific career. However, I am confident that the physicist's ability to communicate could be improved by training and experience that the university could and should provide.

The physicist's ability to communicate may be further impeded by an attitude described in the same report by Susanne Ellis. "Research physicists today feel that if they are able to explain their work in simple terms, they are downgrading it." This attitude is indefensible. In an industrial research effort the physicist's ability to explain to and to be understood by his colleagues and by management is essential, otherwise his work will not have any effect upon society.

Industry's responsibilities

What about the older physicist? What responsibility does industry have to keep its maturing scientific staff current? Industry recognizes and generally accepts a responsibility to keep its scientific personnel from becoming obsolete. Of course, industry is not homogeneous in meeting these responsibilities, but many companies grant their employees time off to attend the university and reimburse them for books and tuition. Even more innovative techniques are being used, such as closed-circuit TV from university classrooms to stimulate continuing scientific education. Further, industry is beginning to recognize that it is not enough to make this sort of ongoing education available. It is management's respon-

sibility to encourage, and in some individual cases even to require, participation.

Having recognized these industrial responsibilities, let's examine the other side of the coin. Scientific competence is not always a matter of returning periodically to the touchstone of the university classroom. Many scientific and technical advances take place in industry. An excellent scientist will grow through his own initiative and through his interaction with his scientific colleagues in industry as well as at the university. These opportunities are not available in every assignment, and management has the responsibility to assure a rotation of assignments that encourage growth of the individual.

Probably even more important to continued scientific growth is the environment provided by management's attitude. If corporate management is sufficiently astute to recognize that truly innovative products, which make major contributions, evolve from intelligent minds being challenged, they will provide, through their probing questions and sincere interest, the necessary challenge to stimulate growth in their scientific staff. David Sarnoff said he succeeded in his scientific enterprises because he had greater confidence in his scientists than they had in themselves.

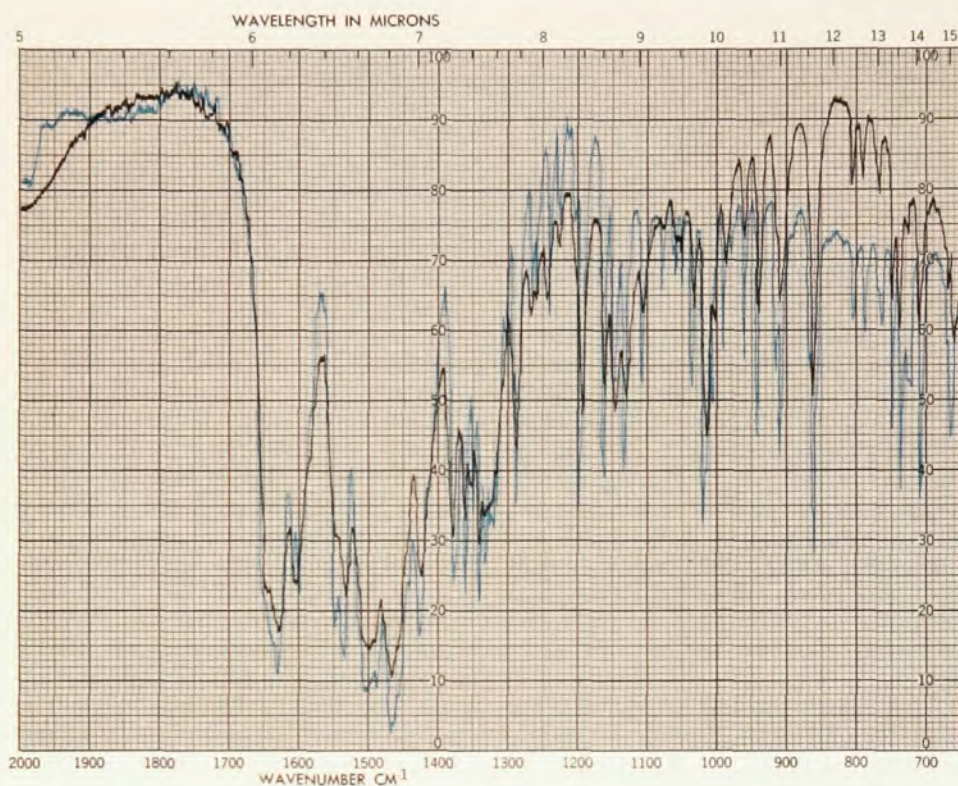
It is not fair to leave this question without recognizing that the initiative, ambition and energy essential for continuing scientific growth are very personal attributes. You can lead a horse to water but you can't make him think. We can, however, gain much confidence by observing that some physicists continue to grow steadily throughout their industrial career even without special support or motivation. They have the ability not only to continue their own scientific growth but to stimulate it in other people.

Anti-industrial bias

One of the greatest problems that we in industry face is the attitude of the student. The university often unwittingly develops in him an anti-industrial bias. He is keenly aware that the top students in the class will be encouraged to join the academic community. Those who do not make this elite group must resort to careers elsewhere, in industrial or government research labs. He who can, teaches; he who cannot must work.

Although I have probably overstated the case, the problem is real. Real but tractable. It arises primarily from misunderstanding. Summer employment of students in industry is a beginning. Postdoctorates in industry for talented PhD's who intend to return to the academic life would help to bridge the gap. Many industrial affiliate programs have been initiated throughout

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the country; however, their success is spotty and not earthshaking. Real understanding comes only through extended periods of interaction. Perhaps the industrial sabbatical, which allows respected members of the industrial research staff to return with pay to the university for a year of combined education and interaction with the academic community, would be an effective means of developing mutual understanding. Consulting by university professors in industry is also a means of providing interaction. However, it is generally felt that the involvement is not deep enough to provide real understanding of the problems faced by industry and the dimensions of their success.

The job market

What will the job market for physicists in industry be during the coming year? I must confess that I do not know. There are signs that the economy is recovering, and estimates for growth of industrial revenue for the coming year are as high as six to eight percent. The Administration in Washington has indicated that our position in world trade depends upon technological leadership both in products and processes. As a result, greater government support for R&D can be expected next year. This too will have a positive effect upon industrial revenues for research and development. It should be borne in mind, however, that changes in research and development funds generally lag behind changes in total revenue. Further, the lustre of research has dimmed, and the spectrum of expenditures will probably shift more toward development than toward research. New development funds will be very specifically aimed at social problems, such as medicine, transportation, education, law enforcement and the environment. All things considered, we can probably expect a steady, small increase in the total number of positions for physicists in industry.

I would like to remind you that there are approximately 12 000 physicists gainfully employed in industrial research laboratories. Their very real scientific accomplishments have resulted in important benefits for society as a whole. Their success makes it worth the effort to improve the processes that convert scientific contribution to social benefit.

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This article is an adaptation of a talk presented at the San Francisco meeting of the American Physical Society, January 1972.

Reference

1. S. D. Ellis, *Work Complex Study: The Match between Academic Training and Employment of Physicists*, AIP Publication no. R 224 (1969). □