FACTORS AFFECTING THE LOCATION OF INDUSTRIAL RESEARCH IN METROPOLITAN AREAS

BY

BURTON GOLDBERG

B. S. TUFTS UNIVERSITY

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SIGNATURE OF AUTHOR_____
Department of City and Regional Planning,
May 21, 1960

CERTIFIED BY_____
THESIS SUPERVISOR

ACCEPTED BY_____
CHAIRMAN, DEPARTMENTAL COMMITTEE ON GRADUATE STUDENTS.

ABSTRACT

TITLE OF THESIS: FACTORS AFFECTING THE LOCATION OF INDUSTRIAL RESEARCH IN METROPOLITAN AREAS

AUTHOR: BURTON GOLDBERG

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An investigation was made of the factors affecting the location of industrial research in a metropolitan area by testing the following hypothesis: metropolitan Boston is a suitable location for a pharmaceutical research facility and such a facility would locate in the central city. There is no significant amount of pharmaceutical research in Boston at present. It was shown that pharmaceutical research has the same general location requirements as other types of industrial research. In order to determine how the general location requirements of a proposed pharmaceutical research facility for Boston would be influenced by Boston's unique physical characteristics, the location pattern of industrial research firms moving within the Boston metropolitan area was analyzed by means of a survey. Accessibility to residences of professional personnel and proximity to educational institutions were the most important general factors for the location of research facilities. The specific functional linkages relevant to the location of pharmaceutical research firms were investigated by means of a survey of major pharmaceutical firms in the country. There was no significant agreement among pharmaceutical firms as to the exact distances that they preferred to locate in reference to related institutions. The general location requirements of research as they were satisfied specifically in the Boston metropolitan area were related to the particular functional linkages required by pharmaceutical research. The analysis supported the first part of the hypothesis and was inconclusive in regard to the second portion of the hypothesis. While the Boston metropolitan area was a suitable location for pharmaceutical research, such a facility could locate either in the central city or suburbs.

THESIS SUPERVISOR

TITLE: Associate Professor of City Planning

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CHAPTER I

INTRODUCTION

This study will test the following assumption: the central city of Boston is a favorable location for pharmaceutical industrial research. This study concludes that, although metropolitan Boston is a favorable location for pharmaceutical industrial research, such facilities could locate either in the central city or in the suburbs.

Drug firms are ordinarily distinguished according to the kind of product they manufacture and how it is marketed.

An ethical pharmaceutical house is a firm which manufactures drug products which are sold by prescription or purchased on the recommendation of a physician.

A proprietary pharmaceutical house is one which manufactures drugs which are sold over the counter to anyone.

Research requirements are more exacting for ethical drug products. However, the once definite distinction between the two kinds of drug firms is fast disappearing as a result of acquisitions and diversifications

within the drug industry and within related and complementary industries.

There are several reasons for studying the pharmaceutical industry. The pharmaceutical industry spends some two hundred million dollars, or close to eight per cent of total drug sales, on research, an amount which is considerably higher than the average for all manufacturing industry.[1] Over ten per cent of the pharmaceutical industry's research dollar is devoted to basic research, in contrast to the average for all industry of four per cent. The pharmaceutical industry, typical of the new, technically oriented industries which are emerging as a dominant force in the American economy, has shown steady growth, largely as a result of innovation, sparked by scientific research.

The Boston metropolitan area is already the locus of a large agglomeration of technical industries engaged in industrial research. In 1955 there were 16,420 persons employed in industrial research in Boston, which accounted for four per cent of the total number of persons engaged in industrial research in the nation.[2] When compared to the two per cent of the

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1 Standard and Poor's Industrial Survey, (New

of the nation's total manufacturing employment found in Boston, it can be seen that concentration of employment in industrial research is almost twice that of all manufacturing employment. The Massachusetts Department of Commerce estimated that 250 research laboratories have been established in Boston since the war.[3] More than one hundred of these facilities have been established within the last five years. The majority of the new establishments have been in the fields of electronics, nucleonics, and precision instrumentation. However, a significant proportion of industrial research in the Boston area is in the field of chemistry, with particular applications to rubber, textiles, food processing, and paper.

Pharmaceutical research, however, is almost non-existant in the Boston area, being only .1% as concentrated as all manufacturing employment.

York: 1959), Drugs, pp. D8-26.

2 National Research Council, Industrial Research Labs. of the U. S., (Washington, D. C.: 1956, U. S. Government Printing Office), 10th ed., passim.

3 The Wall Street Journal, "Boston's Academic Air Sparks Influx of Science-Minded Firms," May 12, 1959.

Assuming that the generalized location requirements for all research activity are the same, then the Boston metropolitan area would appear to be an appropriate location for pharmaceutical research. Analysis of pharmaceutical research as an activity reveals that it is similar in all respects to other industrial research. When considering pharmaceutical research at this very general level as a process, it shares the same locational requirements as other industrial research. But pharmaceutical research does differ substantively in the kind of research in which it engages. The differences involve an analysis of the unique functional relations in pharmaceutical research which might alter the generalized location requirements. Clinical and certain educational facilities are functionally relevant to pharmaceutical research. Although pharmaceutical research, like research in general, is a large-scale, systematic, search for knowledge based on science, it is the kind of science on which pharmaceutical research is based that makes it different from research in general. Pharmaceutical research is based on the life sciences, and, more specifically, the medical and biological sciences, in contrast to other research, which is based primarily on engineering and the physical

sciences proper, such as chemistry, physics, and the mathematical sciences.

The main differences between pharmaceutical research and industrial research in general are reflected in the kinds of scientists employed and the kinds of institutions and facilities which produce the scientists. A comparison of the employment composition of industrial research firms in the metropolitan Boston area with the employment composition of pharmaceutical facilities in the United States will give a good indication of the differences in the kinds of personnel employed (see Appendix C).

Pharmaceutical research facilities employ primarily chemists, biologists, and engineers, in that order. Industrial research in general, however, using such facilities in the Boston area as an example, employs engineers, mathematicians, and chemists, in that order. Industrial research in general employs more technicians than pharmaceutical research. The main pharmaceutical specialty which pharmaceutical research has in common with all industrial research is chemistry.

There are two avenues of approach which can be followed in attracting pharmaceutical research facilities

to the Boston metropolitan area. One approach would be to attract pharmaceutical production. Pharmaceutical research could then be established in conjunction with production. But Boston has disadvantages which affect its ability to attract pharmaceutical production. For example, Boston is relatively distant from the national market. Boston's main advantage is its highly skilled labor force, but pharmaceutical production cannot capitalize on this advantage because it employs mainly semi-skilled and unskilled workers. The second approach would be to attract into the Boston area pharmaceutical research facilities which are capable of being separated from production. Analysis of the different types of research performed by pharmaceutical firms indicates that basic and background applied research will more than likely separate from production. It will be assumed here that this second approach offers the most promising method of attracting pharmaceutical research into the Boston area. The suitability of the area for pharmaceutical research will be demonstrated on three levels. It will be shown that Boston satisfies the general locational requirements which pharmaceutical research shares with industrial research in general. It will also be

demonstrated that Boston satisfies the specific functional requirements of pharmaceutical research which arise from the unique substantive direction of its research activity.

CHAPTER II

THE NATURE OF RESEARCH

Each industry is characterized by a process or a series of processes based upon a particular art, science or craft. In earlier days, when this country's frontiers were still capable of expansion and when resources were still vast, the demand for industry's products could be satisfied at a profitable price by the rapidly increasing population, without regard for new methods or products. Innovation was accomplished in an unorganized way by independent, practical men, or by inventors whose methods involved painstaking empirical trial and error, rather than the scientific method. As the frontiers of the country closed and resources became scarcer, competition became increasingly severe and industry turned to research on a small scale, still unorganized, but conducted by trained scientists. As goods and services became more complex, the technology of materials, processes and manufacturing also became more complex and finally industry was forced to approach innovation by applying an organized, systematic search for knowledge on a large scale.

Research is the organized, systematic search for

knowledge.[1] Knowledge, in this case, consists of a set of scientifically tested propositions and facts. Given an existing set of established propositions, and a new body of propositions, the task of industrial research is to determine whether there are any significant relationships between them which will yield practical applications. The greater the humber of tested propositions discovered, the greater the probability that the addition of new propositions to the old will either produce useful new applications or suggest new hypotheses which will aid in the discovery of still newer propositions. This search for knowledge required men trained in specialized scientific disciplines. Industrial research today differs from previous methods of innovation in that it is organized on a large scale and is based on the systematic methods and specialized disciplines of science.

Research and development is a broad term and means different things to different people. Research is usually differentiated according to the purpose for which it is undertaken. The number of research classifications runs anywhere from two to six, depending on the degree of differentiation. Four classifications appear to indicate a

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1 C. F. Carter, B. R. Williams, Science In Industry, Policy For Progress, (London: Oxford University Press, 1959), p. 8.

suitable degree of differentiation for the purposes of this study.

Basic research is "research on fundamental problems, without any particular intended application to industry."[2] Applied research is research undertaken having in mind a definite application for industry and may be divided into two types: background applied research, which "is designed to increase the store of knowledge on which further investigations may draw," and product- or process-directed research, which is intended to yield a product or a process of a given commercial character.[3] Development is "the application of the existing store of knowledge to a particular industrial problem."[4]

Research, to a large extent, involves the investigation of the unknown, creating in this way new markets and introducing new applications which did not previously exist. It is difficult to foresee the results of an investigation into the unknown and hence it is difficult to estimate the gain to the firm sponsoring such an investigation. Research may be long term; a research project may take eight to ten years to pay its way through new product development.[5] Hence, immediate real costs are difficult

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2 Loc. cit.
3 Loc. cit.
4 Loc. cit.
5 Standard and Poor Industrial Survey, (New York: 1958) p. D24.

to assess. However, despite the unpredictability of much research, the uncertainty is not as great as it might seem. Experience has proved that the eventual net gain from research to the sponsoring firms has been very great and more than worth the risk.[6] The technically oriented sector of the economy is full of growth industries in which research and development are predominant, along with rapid technical advances and a high rate of obsolescence. Research is necessary merely to keep such firms alive, as well as to maintain their competitive leadership.

The difficulty of evaluating inputs and outputs of research in terms of immediate monetary value is inherent in the research process.

Experiments undertaken in scientific research are usually exacting, small scale operations, capable of being closely controlled so that the chance of error may be reduced. Such an operation does not require large quantities of bulky raw materials and supplies. The results of research are not distributed to a market, but are adopted and utilized by the manufacturing facility of the parent firm.

Research is not tied to any one location by the

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6 C. G. Suits, "Opportunity For Basic Research In Industry," Proceedings of a Conference on Research and Development and Its Impact on the Economy, (Washington, D. C.: United States Government Printing Office, 1958), pp. 87-101.

cost of raw material or supplies, nor are transportation costs a significant factor in research location in terms of either market or materials and supplies. Research cannot function, however, without skilled professional and technical people. Research, then, is a labor-sensitive activity and the two factors in this area which may affect location are wage levels and the level of skilled personnel.[7] Results of interviews and responses to questionnaires used in this study indicate that the availability of skilled labor is the most essential factor today in location decisions. Industrial research is relatively insensitive to wage levels for several reasons. In any industrial activity in which exacting and high-quality work is important, competition in reducing costs is not as keen as it is in a mass production industry. Competition is likely to center around the quality of the work, rather than its cost.

Research facilities will locate near available pools of skilled professionals. It can be shown that certain non-economic factors in the environment which are important to a skilled professional in making his decision to live and work in a particular area govern the availability of skilled professional personnel. When the tra-

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7 Martin Segal, Wages In The Metropolis, (Cambridge: Harvard University Press, 1960), pp. 18-31.

ditional emphasis on the internal cost structure of a firm is no longer valid in making a location decision, there occurs a shift to non-economic factors in the environment which are ordinarily secondary factors in location decisions.

CHAPTER III

COMMUNICATION IN RESEARCH AND ITS AFFECT ON LOCATION

The importance of communication in the activities of the individual scientist is revealed in a study which made 25,000 direct observations on a scientifically selected sample of 1,500 industrial chemists.[1] The largest per cent of the scientists' total working time and of their working time in the work area is allocated to scientific communication. The second largest per cent allocation of total working time is spent outside the work area.

Communication may take two forms: written, or oral face-to-face contact. To facilitate written communication a library with a good stock of technical journals and an abstracting service is essential to a research facility of any size. In a survey of Philadelphia industrial research firms, 94% of all employees surveyed were found to have access to a professional reference library.[2] Ninety-two per cent have current professional periodicals and books available for use at work. The opportunity given industrial

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1 R. L. Ackoff, Proceedings of a Conference on Research and Development and Its Impact on the Economy, (Washington, D. C.: United States Government Printing Office, 1958), Pp. 69-72.

2 Alice V. Yeomans, Director, Educational Needs and Opportunities of Industrial Research Scientists in the Philadelphia Metropolitan District, (Washington, D. C. American Council on Education, 1951), Pp. 71-72.

scientists to publish the results of fundamental research facilitates communication, Face-to-face contact, as a means of communication commanding the direct attention of the participants, should not be overlooked and offers an immediate opportunity for clarification of the complex matters usually discussed. Industry can facilitate personal contact through liaison, consultation, meetings or physical proximity. Experts on industrial research state that written communication is not sufficient and that personal contact is likely to be more effective.[3]

Communication is an important factor in increasing the status of scientists in industrial research. Scientists depend on colleagues and counterparts everywhere to appraise and recognize the results of their work. Prompt publication of the results of experiments conducted by scientists engaged in industrial research is one way of enhancing their status. Opportunity for attendance at and participation in meetings of professional societies and seminars at universities is another way to facilitate recognition and increase status. The inferior status accorded the industrial scientist has been a factor hindering industry in recruiting high-quality scientists. Scientists have felt that by working for an organization primarily motivated by profit considerations, the fundamental

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3 Carter, Op. cit., p. 25.

motivations of a scientist to satisfy his intellectual curiosity and to attempt to discover fundamental truths are distorted. Interviews reveal that the government and the universities get scientists of higher calibre than those employed in industry.

Industry has attempted to overcome the status problem in two ways. First, by creating a campus-like setting for its research activities, in order to simulate an academic environment and second, by attempting to increase extra-firm communication, especially with universities, to make the scientist feel he has a share in the creative academic atmosphere.

The high-calibre scientist has the imagination and ability to make the connections between new and established ideas necessary to conceive new hypotheses. Since the factors within the individual contributing to creativity are unknown, research firms must create an environment favorable to the communication of new and old ideas. Contact with a wide variety of new ideas increases the probability of making new applications and of devising new hypotheses.

The fact that research employs scientists specializing in different fields complicates communication. Although specialization is convenient for academic reasons, the search for new products involves knowledge which over-

laps into the interface between disciplines. Communication is easier between scientists in the same discipline that it is between scientists in different disciplines. However, cross-fertilization between different disciplines increases the probability of new ideas. Sources of ideas are found to be both internal and external to the firm.

There are two possible sources of ideas for a research facility which are found within the firm. The large research laboratory can attempt to stimulate cross-fertilization by employing within its own facility as large as possible a number of scientists from different disciplines. However, the large expenditure of money and the administrative difficulties of managing such an establishment limits the degree to which such integration can be accomplished, even in a large laboratory.

Another internal source of ideas is contact with other departments. Sometimes, for scientists, meeting production engineers familiar with the needs and problems of production, or technical salesmen, familiar with the needs of customers, can be a source of new ideas.

In a survey of industrial research administrators in Philadelphia it was found that there were numerous contacts between industrial research laboratories and educational institutions in the form of student employment, the filling of vacancies through school recommendations and

the provision of special courses needed by the employees.[4] Research scientist or engineering positions were most frequently filled by requests to schools and through personal contacts at universities.

There appear to be four principal reasons why external sources of ideas are likely to be important to firms engaged in research.[5] First, a company may wish to add technical skills and facilities to its research and development program which are not presently contained within its own organization. In general, a large firm will seek scientists with the necessary specialized research skills, while a small firm will rely on outside facilities, Second, a laboratory might use outside sources to handle overflow work. Third, a laboratory may obtain objective evaluation from outside sources. Fourth, a research facility may carry on cooperative research programs with external sources of ideas. Examples of such external sources of ideas are: consultants, suppliers, competitors and other industries performing research in related fields (technical improvements in one industry may benefit another), as well as research institutes and government agencies.

The staff of a university is a source of industrial

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4 Yeomans, Op. cit., p. 72.

5 F. E. Lewis, "Development of New Product Idea Sources," Product Development in Small and Medium Size Companies, (New York: American Management Assocation, 1957), pp. 11-13.

consultants. One of the advantages for professionals on the faculty of a large metropolitan university is the possibility of additional sources of income through consulting.

Universities, as part of their educational curriculum, engage in basic research to investigate new hypotheses and to test old propositions. The results of such investigations are constantly being incorporated into the curriculum to keep the body of knowledge in a discipline up-to-date. The university transmits this up-to-date knowledge to its students in the course of the educational process and to other professionals through seminars, conferences at the university or at meetings of the many professional societies.

The industrial research facility can take a more positive approach to securing new ideas by enrolling its personnel at universities to keep abreast of the latest ideas and this has the added advantage of increasing the professional status of the personnel and of enhancing their sense of importance and usefulness to the firm. In a sample survey of the educational status, needs and opportunities of industrial research scientists in the Philadelphia metropolitan district, thirty-seven per cent of the industrial scientists not already holding a doctor's degree indicated a desire for further education.[6] About two-thirds

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6 Yeomans, Op. cit., p. 49.

of these scientists attend fairly frequent conferences or discussion groups during work hours, and time off is granted to seventy per cent to attend courses, professional meetings or conventions. One of the activities most frequently engaged in by the scientists to keep currently informed in their fields was attending scientific meetings.

Determining how much and what kind of research a firm can profitably engage in is important in location decisions. In a small firm the expensive nature of research necessitates a relatively small number of personnel, usually located with the production facility. The small firm is also limited in the kind of research it can undertake. The large firm, on the other hand, engages in research on a wide variety of products and therefore is more likely to have research facilities separate, either according to the nature of the research or to the product on which the research is being done. Many of the general characteristics significant in the location of research facilities vary according to the kind of research performed.

Basic and background applied research must not only constantly be in touch with new ideas, but must also have people with the insight to see new relationships and the imagination to conceive new ideas. Basic research of this type has become an integral part of advanced scientific education at universities and the university has become in

creasingly involved in background applied research. This type of research, therefore, is particularly sensitive to communication outside the firm. Such research, being directed toward what does not now exist, has all the elements of unpredictability previously discussed, which makes it less sensitive to costs and to wages in particular. This type of research most needs skilled labor and even though administrators readily pay the highest price for the rare combination of insight and imagination in their scientists, they have had difficulty in recruiting them. Such research can usually be afforded only by the larger firm. For basic and background applied research, the principal sources of ideas would be research institutes, university research departments and certain government agencies. The basic research facility will therefore locate, with little regard for cost, near pools of high quality professional personnel and where extra-firm communication can be facilitated.

Product- and process-directed research being directed more to what exists, is shorter term in nature and more predictable in regard to output and hence more sensitive to wage costs, less dependent on high quality scientists and less oriented toward outside communication and the university. Such research is more likely to be within the capabilities of a small firm. Communication is oriented within the firm to production engineers familiar with

the firm's needs and problems in regard to products and processes. Industries presently using the product, research institutes, certain government agencies, and university research departments are primary sources of ideas which may be tapped by research facilities engaged in product- and process-directed research. Product- and process-directed research would be located near production, preferably not far from suppliers, industries, and commercial research companies.

Development, being more predictable and concrete than product- and process-directed research, is most oriented toward intra-company communication, most concerned with reducing costs, and least likely to rely on the creative attributes of professional scientists. If a research facility plans to develop a product which, except for minor variations, is identical to other, already established products, then suppliers, competitors, other industries, and research institutes are the best external sources of ideas. When a problem arises in a specific technical field, the individual consultant, specialist, or engineering firm is the best source of ideas. The research institute is of particular benefit to the small firm because it is geared to offer all phases of research and development.

Published communication by scientists in development is not in demand from scientific colleagues, nor is it en-

couraged in competitive industries.

If production is continuous-flow, development will more likely locate in the plant facility. For batch-type production, however, a separate development operation, located close to the plant is possible.[7] Of all phases of research, development is least likely to locate in reference to universities or pools of professional personnel.

Since Boston is not an advantageous location for pharmaceutical production, it is necessary, in support of the hypothesis of this thesis, to investigate whether some types of research have location requirements which are independent of production.

Several factors operate to justify a location for research separate from production. The plant and adjacent industrial areas, with their vibration, noise, dirt and fumes may be unsuitable for a laboratory.[8] An attractive site capable of attracting and impressing devoted scientists may not be available near production facilities. The research scientist is likely to fear control and domination by the production-oriented sector. The co-equal position of research personnel when located away from production may increase the status of scientists and thus

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7 A. E. Smith, ed., Drug Research and Development, (New York: 1948), p. 70.

8 C. E. Mees and J. A. Lurmakers, The Organization of Industrial Scientific Research, (New York, McGraw-Hill, 1950), pp. 352-354.

help attract good scientists. A research facility may locate away from production to facilitate communication with universities and with other firms which may be sources of new ideas. Increased size and diversification of manufacturing facilities through acquisition of smaller firms may favor the decentralization of research facilities. A research facility located away from production may gain in efficiency from simpler organization.

Other factors operate to favor the location of research facilities near production. Ultimately, the results of research must be transferred to production and geographical separation from the plant may cause difficulties in translating laboratory results into production. Contact and familiarity with the plant diminishes as separation increases. The research laboratory can in some respects act as a service unit to the plant by training personnel.[9] Training is more valuable when personnel are acquainted with plant problems. The laboratory may use many plant services, such as protection, maintenance, cafeteria and purchasing, which would be more expensive to provide in a separate location.

Considering these influences in the light of the characteristics of the various kinds of research, the advantage of a research facility located away from produc-

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9 Ibid., p. 353.

tion definitely outweighs the disadvantages for basic and background applied research. From the same point of view, however, the advantage of a research facility located close to production definitely outweighs the disadvantages for product-directed or process-directed research and for development.

In a survey of seventeen major pharmaceutical firms conducted for this study, seventy per cent of the firms replied that they would locate basic research facilities entirely separate from their production facilities. Inconclusive results were obtained on the location of background applied research facilities, exactly one-half of the firms favoring either separate or proximate locations in relation to production. Ninety-four per cent of the firms surveyed favored a location near production facilities for product-directed and process-directed research, while all firms favored such a location for development facilities. The results demonstrate that basic research will most probably separate from production, while a location either near or separate from production is equally probable for background applied research. Pharmaceutical firms are almost unanimously in favor of a location near production facilities for product-directed and process-directed research.

Further investigation of the hypothesis in reference to Boston will therefore be directed toward the location requirements of basic and background applied re-

search in particular.

CHAPTER IV

ADVANTAGES OF A METROPOLITAN LOCATION FOR RESEARCH

Some research facilities are independent of the usual locational requirements essential to manufacturing facilities. It is appropriate, at this point, to discuss how mobile, or foot-loose, a research facility actually is. The question, essential in the investigation of our hypothesis, revolves around a discussion of the relative advantages of a rural or metropolitan environment for the location of a research facility. If the functional requirements of research facilities are such that they are relatively independent of their environment, then either a rural or a metropolitan location would be suitable, and the research lab would exhibit an ubiquitous location pattern making it difficult to justify a location in the Boston Metropolitan Area. If, on the other hand, the functional requirements of research activity are not independent of the environment, then one or the other setting, rural or metropolitan, will have definite general advantages which set it off against the other as a preferred location for a research facility.

Research is a skill-sensitive activity and will locate so as to minimize the cost of recruiting skilled professional and technical personnel. The urban concentration of metropolitan areas offers two advantages to research fa-

cilities which are not available in rural areas or in smaller independent metropolitan areas. It is easier to recruit professional and technical personnel from within a metropolitan area and it is easier to attract professional and technical personnel from another community to a metropolitan area. There are reasons for the advantages of a metropolitan area in this respect. The concentration of industries and research facilities in the metropolitan area offers an existing pool of professional and technical labor.

Professionals prefer access to the urbane cultural atmosphere and superior environment of the metropolitan area. The specialized educational institutions which are primary sources of professional and technical personnel are predominantly located in or near metropolitan areas.

A typical research facility employs two types of skilled personnel: technicians and scientists. Technicians are "workers in positions requiring knowledge of a physical science or engineering, comparable to that acquired through technical instruction, junior college or other formal post-high school training, or through equivalent on-the-job training or experience."[1] Professional personnel are usually defined as "salaried personnel who hold a bachelor's degree or higher degree and who are working at a profes-

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1 Methodology of Statistics on Research and Development, (Washington, D. C., U. S. Government Printing Office, 1959), pp. 102-103.

sional level."[2]

Heavily industrialized metropolitan areas usually contain a large pool of technical personnel because a large per cent of technicians obtain their skill from on-the-job training. Furthermore, the urban concentration of industrial firms is instrumental in supporting specialized technical schools, which also add to the pool of technicians.

In any given area, the resevoir of technical personnel available to a new firm is always in flux. For instance, a firm may obtain skilled technicians by inducing technicians to commute longer than normal distances or a firm may import technicians from other areas.[3] A firm may also induce workers to come from other plants in the area. However, these methods of recruiting personnel may be practiced just as well outside a metropolitan area and may also negate the real advantages of an immediate market of technicians indigenous to the metropolitan area. A research facility located in a rural area is handicapped in two ways. The probability of finding a large enough labor market with sufficient skills to provide technicians is slim. The facility located in such an area must be resigned to a costly training program for a large proportion of its personnel.

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2 Methodology of Statistics on Research and Development, (Washington, D. C., U. S. Government Printing Office, 1959), pp. 102-103.

3 Segal, Op. cit., p. 20.

Characteristics of professional personnel are slightly different. Professional personnel are fairly mobile and there is a national market for their services. This in part explains why the interregional salery differences are relatively insignificant. The best location for a research facility is an area in the vicinity of which scientists may be easily recruited. In contrast to the technicians, the primary source of professionals is the universities, not on-the-job training. The location of universities is preponderantly in or close to the metropolitan areas. The metropolitan areas have the advantage of providing a constant source of new professionals in their vicinity which facilitates the recruiting of professionals when compared to a rival location.

Evidence seems to indicate that, even though a scientist may prefer a suburban location for his domicile, access to facilities in a metropolitan area is essential.[4] The mobility of scientists does not mean that all metropolitan areas offer equal attractions to the scientist; this is evident from the fact that some metropolitan areas have more scientists than other metropolitan areas. The availability of attractive living accomodations and environment varies in different metropolitan areas, along with the factors pre-

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4 Segal, Op. cit., p. 29.

viously mentioned, and thus is responsible for the variation in the size and quality of the professional labor pool.

Another advantage which a metropolitan location offers research centers around the utilization of new and established ideas. Location in a metropolitan area facilitates the communication of ideas. The metropolitan area has always been a source of innovation for several reasons. Heterogeneity and diversity are conducive to cross-fertilization. Educational institutions generate and transmit ideas. External sources of new ideas are likely to be present in a large urbanized area. The advantages of a metropolitan area are applicable to all research facilities because the utilization of professional skills and ideas is a characteristic inherent in research, regardless of the size of the facility.

The reasons for requiring the advantages of a metropolitan area vary according to the size of the firm. The metropolitan area offers more advantages to the small laboratory than to the large, and for quite different reasons. For the small research facility the advantages of a metropolitan location are in the nature of external economies. The specialized functions available in the metropolitan environment external to the firm are responsible for monetary economies within the small facility.[5] A specialized facil-

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5 E. M. Hoover, The Location of Economic Activity, (New York: McGraw-Hill Book Co., 1948), p. 120.

ity in an area, supported by many similar firms, can perform a function more economically than any one of the firms themselves could perform it. A pool of professional labor is an example of an external economy of importance to small research firms. The advantages of a professional labor pool are the same for all sizes of research facilities: recruitment costs are reduced, valuable time is saved, flexibility is increased and the probability of obtaining personnel capable of highly productive output is enhanced.

A large facility can do a lot itself to change the environment and hence is less dependent upon it than a small facility which must adapt itself to the environment. The impact of a large facility is such that establishments offering specialized services or supplies will locate in reference to it. For the large firm, or for a basic research facility located separately, the previously stated advantages of a metropolitan location are important because they are essential for the high quality of work necessary to continue or achieve competitive leadership. For the large research facility the advantages stipulated for a metropolitan location are more in the nature of necessary functional linkages, arising from the need of contacts for the interchange of knowledge, rather than economies in the cost structure of the firm.[6]

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6 P. S. Florence, Investment, Location and Size of Plant, (Cambridge: University Press, 1948), p. 190.

CHAPTER V

PHARMACEUTICAL RESEARCH IN METROPOLITAN AREAS WITH PARTICULAR REFERENCE TO BOSTON

The advantage of large metropolitan areas for the location of research in general and for pharmaceutical research in particular is generally substantiated by an empirical examination of the existing location pattern of pharmaceutical research. There are significant exceptions which do not support the hypothesis of the suitability of the Boston area for research. The Boston metropolitan area has no pharmaceutical research and at the same time there is a large concentration of pharmaceutical research in two small areas of the Midwest. Analysis of the location requirements established thus far for pharmaceutical research is assumed to be correct. An analysis of the reasons for the existing location pattern of pharmaceutical research reveals an economic and technological lag. Analysis of recent trends shows that the location pattern of pharmaceutical research is changing. Concomitant with this change, the needs of pharmaceutical research are becoming more like the needs of research in general. That these changes favor a location in the Boston metropolitan area, is shown by demonstrating the advantages of the area for both research in general and for pharmaceutical research in particular.

Eighty-two per cent of pharmaceutical employment is concentrated in the Middle Atlantic and East North Central regions of the U. S. The concentration of pharmaceutical employment is these two regions corresponds to a significant concentration of all manufacturing employment in these same regions. A localization coefficient of .28 for the pharmaceutical industry indicates that the regional employment concentration in the pharmaceutical industry is only twenty-eight per cent greater than the regional concentration of all manufacturing employment (see Appendix D). A particular industry which has an employment concentration exceeding by fifty per cent the concentration of all manufacturing employment, or which has a coefficient of localization greater than .5, is normally considered to reveal an extremely differentiated, centralized location pattern.[1] There is a substantial amount of coincidence, region by region, of pharmaceutical employment with employment in all industry.

The concentration of pharmaceutical research in relation to all manufacturing employment is higher than pharmaceutical production and is reflected in a higher localization coefficient for pharmaceutical research of .37. Ninety-one per cent of pharmaceutical research is in the Middle Atlantic and East North Central regions of the country. The

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1 Florence, Op. cit., pp. 38-40.

Middle Atlantic region's share of the country's pharmaceutical research is substantially greater than its share of the country's pharmaceutical production. The East North Central region's share of pharmaceutical research employment is less than its share of pharmaceutical production employment. The high coefficient of linkage between research and production of .89 indicates a high coincidence in the location of both activities. The apparently high geographical coincidence of research and production is not really high when one considers that two components of the same industry are being compared. Fourteen per cent of pharmaceutical research does separate from production and once separated concentrates in the large metropolitan areas of the Middle Atlantic states.

The relatively large size of the geographical region used for the purposes of analysis obscures the still greater concentration of pharmaceutical research which occurs in smaller, specific areas within the region. Sixty-nine per cent of pharmaceutical research in the nation is located in six standard metropolitan areas. Four of these metropolitan areas are among the largest in the country in population. The location quotient expressing the relationship between the per cent of the national total of pharmaceutical research to be found in a standard metropolitan area and the per cent of all the nation's industry in the same area indicates concentration of pharmaceutical research in larger

metropolitan areas. The Philadelphia and the New York - New Jersey standard metropolitan areas, for instance, have respectively three, and two-and-one-half, times the concentration in pharmaceutical research they have in all industry. The location quotients for pharmaceutical research are extremely high for the medium size metropolitan area of Indianapolis and the relatively small city of Kalamazoo. With these two notable exceptions, pharmaceutical research tends to concentrate to a greater extent than all industry in the largest standard metropolitan areas of the country.

The present location of pharmaceutical research is a result of the influence of the location of pharmaceutical production facilities. Most of the older pharmaceutical houses started as retail pharmacies. Some of the older, urbanized areas which now represent the country's largest metropolitan areas had an early start in incubating the pharmaceutical industry because of the ingenuity and business acumen of a few particular entrepreneurs. The establishment of the first school of pharmacy in Philadelphia was influential in promoting the cluster of pharmaceutical firms in that area.

The pharmaceutical industry has had a long history of individual or family ownership. It was one of the last industries to succumb to corporate ownership, indicating the strong influence of the private owners in determining the industry's policy. The private owners' strong predilection for tradition resulted in maintaining facilities at or near the

original location despite changing trends in economics, technology and in the distribution of population.

The oligopolistic nature of the pharmaceutical industry has abetted the sway of tradition over economic change.[2] The product of the pharmaceutical industry is a high value-added product, is small in bulk and can easily be distributed to a national market from one location. High sunk costs in plant and equipment provide still another explanation for the persistance of plant location patterns. The high relative concentration of pharmaceutical research in Kalamazoo and Indianapolis, represented by the integrated production and research facilities of the Upjohn and E. L. Lilly firms, is explained by the preceeding factors.

Several factors indicate a recent change in the location pattern of research facilities which promises to continue in the future. This change consists of a declining influence of manufacturing facilities on the location of research facilities. The fierce competition centering around competitive obsolescence and leadership in innovation wrought by the introduction of an emphasis upon research since the 1930's is one factor. Only one large pharmaceutical firm re-

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2 J. D. McEvilla, "Price Determination Theory in the Pharmaceutical Industry," Drug and Cosmetic Industry, vol. LXXII, January, 1958, p. 34.

mains under private ownership and the new responsibility to corporation stockholders will favor economic reality over tradition. The trend for pharmaceutical firms already in the industry is to diversify by acquiring independent, smaller, separately located facilities and this runs counter to any trend for integration of production and research facilities.[3] The high profits of the pharmaceutical industry have encouraged entry into the field by related industries seeking to diversify.[4] This trend will be responsible for new investment in research, more acquisition of independent pharmaceutical firms, with a resulting de-emphasis on integrated research and production facilities and the introduction of new criteria in location decisions. The recent trend among established pharmaceutical houses is to create non-profit basic research institutes in separate building facilities in the general vicinity of their production and other research facilities. The establishment of such institutes is felt to increase the status of the firms' research personnel. Recent developments in the pharmaceutical industry which reflect this trend are the establishment of the Bristol-Myers centralized research facility, near Rutgers University, Parke-Davis Company's separate basic research

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3 "Fermentation," Industrial and Engineering Chemistry, Vol. LI, September, 1959, p. 1086.

4 "Drug Industry: Pause in a Miracle Climb," Chemical Week, Vol. LXI, 1954.

facility near the University of Michigan medical center, and Merck and Winthrop-Sterling's separate basic research facilities.

All of the above factors are changing the traditional thinking of the pharmaceutical industry and the change in the industry's thinking is being reflected in its location decisions. Let us now examine what claims the Boston metropolitan area may have to attract the attention of the pharmaceutical industry in its new attitude towards the location of research facilities.

An analysis of the advantages which the Boston metropolitan area offers for industrial research in general is also applicable in showing the advantages the area offers to pharmaceutical research. Boston's two main advantages for industrial research have to do with the availability of scientific and technical personnel and with the communication of ideas.

The ability of the Boston area to retain its skilled and professional personnel has resulted in a relatively permanent, expanding pool of technical and scientific labor. This attractive and retentive quality of the Boston area depends on two basic factors: the number and quality of its institutions, and the attraction of its cultural and living environment.

In comparing Boston's institutions with those of various other metropolitan areas, discrepancies in size between

metropolitan areas were taken into account in order to examine the real capacity of institutions which was not a direct result of the relative size of the metropolitan area (see Appendix E).

The Boston metropolitan area has eleven major colleges with a total undergraduate enrollment of 81,720 and a total faculty complement of 8,318. The full significance of the educational complex in Boston can more readily be grasped when such figures are compared to total undergraduate enrollment in the New York metropolitan area, equated on the basis of the sizes of the two metropolitan areas. On this basis, the New York metropolitan area has only twenty-nine per cent of the undergraduate enrollment of the Boston area. Administrators and most people employed in industrial research agree that education beyond a Bachelor's degree is desirable for scientists in industrial research. Using this criterion we find that, by examining in the same manner equated figures for graduate school enrollment in the New York, Boston, and Philadelphia areas, Boston's supremacy is again established in regard to the numbers enrolled in university graduate schools in engineering and the physical sciences. Boston's advantage in quantity is still quite distinct in graduate enrollment, even though there is a less marked advantage than in undergraduate enrollment. Proportionally to size, New York and Philadelphia have only forty-seven and fifty-seven per cent

of the graduate enrollment that Boston has.

In the less mensurable area of the quality of its institutions, Boston would appear to be favorably situated. The high quality of its institutions and the great esteem in which they are held attract students and scientific personnel from far outside the area. Harvard and M.I.T., for example, are recognized throughout the world as institutions of the highest quality. The reputation of such institutions as these has in part provided the impetus for the growth of industrial research in the Boston metropolitan area. Realtors who have located new industrial research firms in the Boston area have found that their most frequent request is for proximity to either one of these institutions.

A survey of industrial research firms within the Boston metropolitan area which was undertaken for this thesis reveals unanimous agreement that the availability of educational institutions in the Boston area is excellent. Sixty-five per cent of the respondents to our questionnaires said that the availability of scientific and skilled personnel was excellent and thirty-five per cent rated Boston good in this respect. By restricting the survey to firms within the area, results have been biased because these firms, by their very presence in the area, already indicate a preference for it. However, if firms outside of the area were surveyed, then there would probably be the prob-

lem of evaluating responses based on limited knowledge. Furthermore, responses to other similar items in the survey were not always unanimous or favorable, indicating that firms within the area can be somewhat objective, at least, in their evaluations of the area.

Research firms responded most favorably on the less tangible but important factors of availability of attractive living accomodations and environment, and on the quality of the cultural institutions. Ninety-four per cent of the respondents thought that the quality of cultural institutions was excellent. Seventy-six per cent of the respondents thought that the availability of attractive living accommodations and environment was excellent. The accessibility to the ocean, the rolling countryside and small ponds, and the historical distinctiveness and flavor of some of the communities within the area, have been cited as factors contributing to a favorable environment in the Boston area.

The stimulating exchange and communication of ideas with universities and with other firms performing industrial research in the Boston area results in what the Wall Street Journal calls an "intangible, but nontheless important, atmosphere of creativity." Firms engaged in research like to be near institutions where there is a probability that major discoveries will be made. M. I. T., for example, maintains an industrial liason department to assure that the time lapse between a basic discovery and its industrial

application is reduced. The variety of professional skills in the Boston area has resulted in the communication of ideas as a business. Boston, together with New York, is one of the major centers for consultants. Universities in the area are the main source of experts who can be called upon to solve special problems. Boston is also a major center for commercial research. Such firms as Arthur D, Little and National Research have a diversity of talent capable of performing research in a wide variety of fields. The Wall Street Journal's evaluation of the Boston area found that "The wealth of university and industry research talent here makes for a stimulating, idea-generating atmosphere for scientists to live and work in."

It can be demonstrated that Boston satisfies the specific functional requirements of pharmaceutical research related to the unique substantive direction of its research activity. Boston compares favorably to New York and less favorably to Philadelphia in regard to its undergraduate enrollment in medical schools and pharmacy schools. Philadelphia has ten per cent more undergraduate students in medical schools than Boston does, while New York has about two thirds fewer. Boston maintains a slight advantage over Philadelphia and a distinct advantage over New York in its undergraduate pharmacy school enrollment. Boston's slight disadvantage in regard to medical school enrollment is of less significance because a relatively small per cent of

graduating medical school students go directly into research, compared to graduate students in the medical schools.

Boston's advantage in graduate enrollment in the medical sciences, life sciences, and physical sciences related to pharmaceutical research is distinct and in some cases exceeds its advantages for industrial research in general. Graduate school enrollment is particularly significant in evaluating Boston's capabilities for pharmaceutical research because graduate schools are specifically oriented toward research and a large proportion of graduate students continue in research after graduation. Boston has a decided advantage over Philadelphia and New York in the size of its graduate medical school enrollment and a definite, but less decided advantage, in enrollment in university graduate departments in the physical sciences of biology and chemistry. Boston, then, compares favorably in most respects with other metropolitan areas in providing future research scientists suitable for pharmaceutical research. It has been estimated that thirty-five per cent of the graduates who expect to go into medical research remain in Boston, five per cent remain in New England, and fifty-two and one-half per cent go elsewhere in the nation. When this fifty-two and one-half per cent exported elsewhere is deducted from the total enrollment in Boston's medical school graduate departments and the resulting figure is compared to other metropolitan areas, Boston's enrollment still exceeds that of New York and is on

a par with Philadelphia. However, when it is considered that Philadelphia also must export a certain per cent of its enrollment, Boston still has a decided advantage in the relative size of medical school graduates remaining within its own metropolitan area. When it is considered that the 52.5% going to the rest of the country is split up among numerous metropolitan areas, the 35% remaining in Boston has an even greater significance. It is concluded that pharmaceutical research located in the Boston metropolitan area would have a decided advantage in regard to availability of scientific personnel for its research activities, compared to other large metropolitan areas in the East.

Boston's reputation as one of the major medical centers in the world is based on the excellent quality of its medical institutions and hospitals, a factor which cannot be measured quantitatively. Information obtained from interviews lends support to the high evaluation of the quality of medical facilities in the Boston area. Applications for admission to Boston's medical schools and for residence at Boston's hospitals are received from all over the nation and competition for admission is extremely keen compared to other medical centers. Boston is thus assured of obtaining a high quality of medical research talent. Harvard Medical School has maintained a policy of emphasizing and encouraging medical research in its student medical program to a

degree not practiced by other medical schools. It has been Harvard's established policy to assume the role of providing research men and specialists for staffs of other universities and medical schools throughout the nation. The desire of departing Harvard staff members to remain in the excellent professional atmosphere of the Boston area has led a significant number to take staff positions at other Boston medical schools. At present, Tufts University's research activities are small compared to Harvard's, but the school plans to expand its research facilities by purchasing a fourteen-story building now used by the garment industry. Within six years Boston university plans to have built, at a cost of approximately sixteen million dollars, one of the largest teaching, research, and patient care facilities in the country, linking Massachusetts Memorial Hospital and Boston City Hospital to Boston University Medical School. A three million dollar, ten-story, medical research building has already been completed.

The compact, concentrated nature of Boston's three medical centers, all concentrated within or near the downtown area, facilitates communication. The three medical schools maintain excellent libraries and the proposed seven-and-a-half-million dollar consolidation of the Boston Medical Library with the Harvard Medical Library will result in the second largest medical library in the country. Other medical book collections are at M. I. T. and in decentral-

ized teaching hospital libraries throughout the city. Approximately 1,300 medical professionals, experts in various fields, are on the teaching staffs of medical schools and affiliated teaching hospitals in the Boston area and are a valuable source of expertise from which a pharmaceutical research facility could derive great benefit. When comparative size is taken into account, Boston's combined medical faculty is sixty per cent greater than New York's and is almost on the same level as Philadelphia.

In the fiscal year 1958, fourteen of the largest pharmaceutical firms in the country gave a total of $128,656 for research to be undertaken in one of the large medical schools in Boston (see Appendix H). Two factors indicate that the pharmaceutical firms' utilization of Boston's medical research facilities is a token, rather than an effective utilization. The sum donated by pharmaceutical firms is relatively small (4%) compared to the total funds granted to medical research in Boston. Pharmaceutical firms appear to be content to maintain liason with Boston's research facilities over long distance.

There are many Boston firms with unique specialties which could complement the research of pharmaceutical firms. Two of the most promising developments which may revolutionize pharmaceutical research in the future lie in areas which are outside the pharmaceutical firms' direct interest or capabilities. One development possibility, the use of radio-

active isotopes to trace the pharmodynamic action of drugs, is the special domain of two firms in the Boston area: Tracer-Lab, and Baird Atomic. The other development possibility, the use of Van de Graaf generators for laboratory sterilization, is the exclusive domain of Boston's High Voltage Engineering Corp. Medical equipment firms in the Boston area could develop, in cooperation with pharmaceutical firms, more efficient modifications of present medical research equipment. Two such firms in the Boston area are The International Equipment Company, and the Sanborn Company.

The Boston metropolitan area satisfied the two most important general locational requirements for pharmaceutical research. The Boston metropolitan area satisfies the specific functional requirements of pharmaceutical research to a greater degree than other large metropolitan areas in the East. Boston most satisfies the particular criteria important to pharmaceutical basic and background applied research. It has been indicated that pharmaceutical production, and therefore the kind of pharmaceutical research which must locate in conjunction with production, is not likely to locate in Boston. Since basic and background applied pharmaceutical research are the kinds of pharmaceutical research most likely to locate separately from pharmaceutical production, it is concluded that the Boston metropolitan area is a suitable location for basic and background pharmaceutical research.

It has been established that for industrial research in general there are definite advantages to a metropolitan location. Pharmaceutical research has the same unpredictability, quality-centered competition, obsolescence and sensitivity to skilled labor as research in general does. It should therefore show the same generalized locational preferences for metropolitan areas as other research. However, there is a difference between pharmaceutical research and other industrial research, resulting from the unique character of the research and from the application of the end-product, which is reflected in different functional linkages and therefore in different locational considerations.

Clinical facilities for testing drugs are necessary for pharmaceutical research. Teaching hospitals affiliated with medical schools are the best facilities for clinical testing. Expert supervision and evaluation of results by a professional staff is assured. Teaching hospitals are research-oriented as part of their educational function. Many such hospitals are specialized and have more cases of both common and rare diseases in their respective fields, allowing larger scale clinical tests with more valid results. The two general functions of educational institutions are to train skilled professionals and to generate new ideas. More specific functional relationships which relate educational institutions to pharmaceutical research are: availability of professional person-

nel, coordination of basic research, availability of expert consultation, professional training and advancement for personnel, and participation in conferences and meetings. Medical schools, general educational institutions, and other specialized educational institutions are three types of educational institutions which have functional relevance to pharmaceutical research.

Medical schools conduct scientific research on problems of clinical significance. They provide a continuing supply of skilled professionals, primarily doctors, but also scientists trained at the graduate level in various specialties, who have a general knowledge of problems in practicing medicine, as well as in their own scientific specialty. In conjunction with teaching hospitals, schools provide a source of new ideas from research and clinical practice in seminars, conferences, clinical rounds and association meetings. Medical schools also provide professional books and technical journals to facilitate their research activities.

General educational institutions provide trained scientists in the basic scientific specialties necessary for research. Such training is accomplished through undergraduate and graduate research programs in biology, chemistry and physics. Universities are sources of new ideas in the basic physical and life sciences, but with fewer clinical applications. Specialized educational institutions such as pharmacy schools provide pharmacists who conduct research

on the dosage formula for pharmaceutical firms. Medical technician schools train high school graduates in laboratory techniques so they can act as the hands of the professional research man in less technical operations. If the locational requirements of these institutions necessitate a metropolitan location then this would provide functional linkage for locating pharmaceutical research in a metropolitan area.

Teaching hospitals are usually located in or near the center of the city. Highly specialized functions can be supported only from a large metropolitan area and its hinterland. The urban core is still the most accessible location by all modes of transportation from the metropolitan area and its hinterland. Nursing staffs are more easily obtained in a central city. The higher incidence of disease in the older, built-up slum sections of the central city is in fact an advantage to a hospital's urban location. Hence, it is concluded that a metropolitan location is necessary for teaching hospitals.

For medical schools one of the basic resources for investigation is the patient in the hospital and schools therefore gravitate towards urban-based clinical facilities. Most colleges locate medical facilities in the urban center, away from the main campus for these reasons. Teaching is carried out in both hospital and school, making proximity convenient for the staff. Specialized labs in teaching hospitals may

facilitate research in near-by medical schools. Larger general educational institutions are most often located in metropolitan areas because they can receive students from the area and its hinterland. In the older cities such a location most likely would be in the center of the city or in the immediate inner ring. In newer cities, universities may be f found in a country-like setting in the suburbs. In some cases state universities, and some of the older Eastern colleges are located outside the metropolitan area, but only in rare cases far from urban agglomerations. The specialized nature of pharmaceutical schools and medical technican schools impels them to rely on the concentrated metropolitan area for support. It is concluded that educational institutions which have functional relevance to pharmaceutical research are most often found in metropolitan locations.

Having established the metropolitan character of pertinent educational institutions, it is necessary to determine whether the specific functional relationships with pharmaceutical research are such that these institutions can act as locational referents, influencing pharmaceutical research facilities to locate within a metropolitan area. Questionnaires were sent to twenty-seven of the major pharmaceutical firms in the country (see Appendix F). Acknowledgements were received from twenty firms. Out of these twenty firms seventeen answered the questionnaires. It is estimated that these seventeen firms account for a major share of pharma-

ceutical research and for over eighty per cent of pharmaceutical sales in the U. S. Ranges of mileages were offered as choices for each of the functional linkages thought to be important for pharmaceutical research. All replies to the survey indicating that a location within one to twenty miles of an institution was desired will be taken as indicating that functional dependency is of such a nature as to require a metropolitan location. Over two thirds of the respondents in the survey indicated that some degree of functional linkage with hospital clinical testing facilities was desired. It was assumed that a preference of from one to twenty miles to a particular facility would constitute a linkage. The clinical testing done by pharmaceutical firms is sometimes carried out in metropolitan areas on a national scale and over long distances. Large firms employ a staff of medical men to provide liason with hospitals and doctors for the scheduling, supervising and evaluating clinical tests. Pharmaceutical firms have had problems with clinical testing. On the surface there appear to be enough hospital cases for clinical testing, but the additional requisite of having qualified clinical investigators results in a shortage of hospital cases for clinical testing. Qualified clinical investigators are scarce. Hospitals and physicians have been reluctant to schedule too many clinical tests because they may interfere with allocation of time to the more basic function of caring for the sick and performing research projects

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of their own choosing. Pharmaceutical companies have had to resort to subtle lures to induce the cooperation of doctors. Prestige, publication of results and grants for basic research are the inducements offered to secure the necessary doctors and hospital patients for clinical testing. Negotiation for adequate clinical testing for drugs requires the frequent face-to-face contact made possible only by some degree of physical proximity to teaching hospitals in the urban core. Because of the difficulty and delicacy involved in such negotiations, long distance liaison is a poor substitute for physical proximity in communication. It is concluded that from the point of view of availability of the best clinical testing facilities, a location in or near a metropolitan area is necessary for pharmaceutical research facilities.

For each possible functional relationship of pharmaceutical research facilities with educational institutions, over half of the respondents indicated that a metropolitan location would be necessary. It is conclusively shown that metropolitan educational institutions can attract pharmaceutical research facilities to locate in a metropolitan area. The degree of unanimity indicated for each functional tie can be taken as an indication of the relative strength of the functional tie for pharmaceutical research as a whole. On this basis, the educational institutions strongest link is the professional training and advancement it can provide

people in pharmaceutical research. The opportunity the educational institutions provide for pharmaceutical research facilities to participate in professional conferences and meetings and to utilize experts available for consultation is the next strongest link for a metropolitan location. The weakest links educational institutions provide to pharmaceutical research facilities are coordination of basic research and the availability of professional personnel. Results of investigations suggest that a few firms prefer to maintain liaison with basic research over long distances despite the fact that it has been found that really fruitful basic research depends on face-to-face contact. One might infer that for some pharmaceutical firms basic research is still more of a desire than a reality and that basic research is really used more for public relations purposes and as a lure for clinical testing than it is to maintain competitive leadership. In regard to availability of professional personnel, one prominant firm replied, "We would not consider this to be a crucial factor since recruitment of professional personnel would rarely be limited to an educational institution near by. Experience has shown that regional preferences exist to a greater extent than metropolitan preferences." It might be inferred that pharmaceutical research differs from other types of industrial research in that competition for professional personnel is not as keen. Pharmaceutical firms do not

have to allocate as significant an amount of funds to recruit able people as do, for example, electronics firms. This might further suggest that only when the cost of recruitment is high will proximity to key institutions be considered necessary. However, since creativity and imagination have always been relatively rare, there will always be a scarce supply of high calibre scientists, regardless of the type of firm or its cost structure. The relatively low standing of the availability of professional personnel, coupled with the comment quoted above, suggest that the incentive for quality-centered competition in pharmaceutical research is less than in some other technically oriented industries. Evidence seems to point to the conclusion that differences among large metropolitan areas as to the amount of professional personnel and research activity, indicate that there must be some metropolitan preferences on the part of professional personnel. That the region confers preference on a metropolitan area would seem to run counter to the established dominance of the metropolitan area over its regional hinterland.

Fifty per cent of the pharmaceutical firms surveyed in this study preferred to locate a research facility separately from production, outside the metropolitan area. Thirty-nine per cent of the firms indicated that they preferred a location outside a metropolitan area if they were

to locate a research facility in combination with production facilities. Pharmaceutical firms show a definite preference for metropolitan areas when locating a research facility in combination with production. Production has the effect of pulling the location of research facilities more within the sphere of the metropolitan area than if such research facilities were to locate by themselves. It can be concluded that a metropolitan location is considered more important for production than it is for research. When the seventy-one per cent response of firms indicating a desire for a functional linkage with metropolitan areas is compared to thirty-nine to fifty per cent of the respondents who expressed definite preferences for locations outside a metropolitan area, there appears to be a contradiction between functional necessity and expressed preference. The summary question (see item 6, Appendix B) regarding location of research firms was purposely phrased in terms of names of parts of the metropolitan area in order to determine if there were any "image" value which certain portions of the metropolitan area have for the firms. The contradiction mentioned above suggests that there exists a negative image of the metropolitan area and that this image has not been reconciled with the functional needs for certain institutions most likely to be found within the metropolitan area.

Comments and letters received with questionnaire responses indicated that most firms answered the questionnaire in terms of their present location. Thirty-nine to fifty per cent of the firms expressed preference for a location outside the metropolitan area and, at the same time, seventeen out of the nineteen firms were already located in a large standard metropolitan area, as defined by the U. S. Census. The interpretation given the term "metropolitan area" by the respondents differed from the standard use of the term as defined by the U. S. Census. Most of the large pharmaceutical firms queried were located near large satellite cities in the largest standard metropolitan areas in the country. It is probably difficult for such firms to visualize themselves as being in a functionally dependent portion of the larger metropolitan area. Because of the nature of the questionnaire, the preferences expressed for a location outside the metropolitan area by a significant number of respondents is not a meaningful as the indirectly expressed desire for certain functional linkages with institutions in the metropolitan area.

CHAPTER VI

FACTORS INFLUENCING THE LOCATION OF EXISTING RESEARCH FIRMS WITHIN THE BOSTON METROPOLITAN AREA

Factors significant for the location of research firms within the metropolitan area were investigated by means of interviews and questionnaires (see Appendix A). Firms having industrial research laboratories which have moved in the last five years within the Boston metropolitan area were sent questionnaires. For the purpose of this analysis, industrial research was construed as meaning a separate, permanently established research staff engaged in research, development or product improvement. Teams temporarily recruited for research, or assembled from operating staff were not included.

A comparison of the National Research Council's listing of industrial research facilities within the Boston area in 1955 with the 1960 New England Directory of Manufacturers and the U. S. Small Business Administration's list of Small Research and Development Companies, 1958, indicated that nineteen firms sponsoring industrial research had moved within the Boston metropolitan area during the last five years. Questionnaires were sent to all nineteen firms and eighteen were returned answered. Since one firm replied that industrial research was not an important consideration in its location decision, this questionnaire was excluded from the sample. Fifty-four per cent of the firms with industrial

research facilities moved from a central area to a suburb. Twenty-four per cent moved from one suburban area to another. Twenty-four per cent moved from a central area location to another central area location. Thirteen firms in the sample are presently located in the suburbs, compared to four located in the center of the metropolitan area. It is concluded on the basis of these gross results that firms with industrial research facilities definitely favored a suburban location when moving within the metropolitan area.

Pharmaceutical research is absent in the Boston metropolitan area. An analysis of existing industrial research firms will be made to give an indication of the unique structural elements of the Boston metropolitan area as they affect the location of industrial research. The basic assumption is that pharmaceutical research is similar to other industrial research in its general location requirements and that the factors important in the location of industrial research firms in the Boston area would be of the same importance to pharmaceutical research firms if they were to locate in the Boston area. The validity of this assumption has been established previously in this study.

Availability of research personnel was considered the most important factor for research firms moving within the metropolitan area. Over half of all the firms surveyed

indicated that this was essential in locating within a metropolitan area. This was the only locational factor in the survey given an essential rating in the questionnaire responses. Most importance was attached to this factor by firms in the suburbs and more particularly by firms moving from the central city to the suburbs. A move to the suburbs by scientists, as part of the migrating middle and upper-middle class income groups, has influenced the movement of research firms toward the suburbs. All firms, regardless of their location, were satisfied with accessibility of research personnel. Accessibility of research personnel cannot be termed the single most important factor influencing the movement of research firms to the suburbs, because of the unanimous satisfaction of all firms, in all parts of the metropolitan area, with research personnel accessibility. The location of industrial research firms in relation to the place of residence of scientific personnel in metropolitan Boston merits closer examination.

The metropolitan Boston area was divided into seven sectors, along major radial arteries from the city (see appendix H). All sectors, in turn, were divided into five rings at five mile intervals from the center of the city. All data used represent 1955 employment figures.

The main concentration of industrial research employment occurs first in the northwest sector, second in the southwest sector, and third in the western sector.

These results suggest that research follows the movement of the middle and upper-middle income groups west from the city, and on the surface supports the contention that moving from the central city to the suburbs is influenced by the location of scientists' residences.[1] The main concentration of industrial research firms occurs first in the central area, second in the inner suburbs, and third in the outer suburbs. The jump from the inner to the outer suburbs is significant and probably indicates the influence of the increased accessibility resulting from the construction of Route 128. It can be seen that in 1955 industrial research was preponderantly concentrated in the central area and inner suburbs. The differential is so great between the central area and the outer suburbs that it seems unlikely that it could be completely overcome in five years. However, evidence from the movement of the sample firms would seem to indicate that the gap has been closed considerably in the last five years. The greatest concentration of research employment occurs in Cambridge, Waltham, and Boston, followed closely by Beverly, Concord, and Watertown. The distribution of chemists and engineers by residence in the Boston area was used as representative of areas of residential preference for professionals. Engineers reflect primarily

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1 W. Firey, Land Use in Central Boston, (Cambridge: Harvard University Press, 1947), p. 71.

the type of professional most often employed by research firms located in Boston, while chemists are employed by all types of research firms, particularly pharmaceutical research. The sectors of the Boston metropolitan area with the highest concentration of professionals are, first, the northwest sector, second, the southwest sector, and, third, the west sector. The rings having the highest concentration of professionals are, first, the central area, second, the inner suburbs, and, third, the middle suburbs. The distribution of the residences of professionals follows the distribution of industrial research firms in all but one respect. There is no jump to the outer suburbs as is the case with industrial research firms. The high coincidence of residential distribution patterns and industrial research facility distribution patterns indicate that the location of residence does influence the location of industrial research, or vice versa. The time sequence seems to indicate that industrial research firms, rather than professional personnel, were first to take advantage of the new accessibility patterns offered by Route 128. It is concluded that professional scientists were influenced by the location of industrial research firms, rather than the opposite. It can be inferred that other factors important to research firms were also responsible for the migration of industrial research firms to the outer suburbs. The greatest concentration of professionals

occurred in the following cities and towns, in order from greatest to least concentration: Boston, Cambridge, Belmont, Arlington, Lexington, and Brookline. Boston and Cambridge are the only cities which had both a concentration of professionals and industrial research firms, indicating that they are, in a sense, complete functional communities. The relative scarcity of professionals in Waltham suggests that it is a more specialized research center and possibly a place of residence for lower income people. The relative scarcity of industrial research in Belmont, Arlington, Lexington, and Brookline indicates that they are specialized places of residence of professional personnel. It is sufficient for the purpose of this study to know that there exist areas of residential preference for professional people. The reasons why particular towns are preferred over other towns are interesting, but beyond the scope of this study. For the purposes of this study, it is sufficient to conclude that research facilities are established first in the suburbs to satisfy other important location requirements and that professional personnel then locate in proximity in order to shorten the trip to work. Once the pattern has been reenforced by other firms, areas of residential preference develop near industrial research facilities. New firms will seek to locate near existing professional communities because first, they wish to shorten the trip to

work of the new professional people they bring with them and, second, because they wish to capitalize on attracting professional personnel already within the metropolitan area. The chance of attracting such personnel is more probable if the firm locates to minimize the trip to work for as many employees as possible.

The foregoing analysis is static, dealing with a cumulative summary of past location decisions. The distribution pattern of research laboratories and of the place of residence of professional personnel is the result of a feedback effect from a pioneer firm which initially decided to locate in a particular place. The foregoing analysis assumed that the relationship of research laboratory to place of residence was the only factor which had influenced past location decisions. Since this is not a correct assumption, it will be necessary to examine the motivation of some actual firms in locating their research facilities as reported in interviews and in the responses to the questionnaires.

Interviews revealed that transportation is important chiefly in relation to accessibility of personnel. Firms located in the suburbs are accessible over major highways by car or by car-pools. Although this aspect was not specifically covered in the survey, the location of suburban industrial research along major highways and interchanges is evident from inspection of the data and from

the distribution pattern of all suburban industrial research firms in the metropolitan area. Interviews and a study of firms located on Route 128 confirm the importance of highways and the automobile as the major means of access for personnel working in suburban industrial research firms.[2]

Availability of public transportation does not appear to be an important factor in the location of industrial research firms. Lack of public transportation does not deter firms from moving away from the central city to the suburbs where no public transportation is available. Without regard to original location, 88% of the suburban industrial research firms thought that public transportation was unimportant. Without exception, all firms which moved from the center of the city to the suburbs considered public transportation to be unimportant and only one-third of such firms had public transportation in their new locations. For firms moving from suburb to suburb, however, a distinctly different response was obtained in reference to public transportation. Seventy-five per cent of such firms considered public transportation important and had available public transportation at their new location. Most suburban public transportation operates within a single town or contiguous towns. It would appear that firms

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2 A. J. Bone, Economic Impact Study of Massachusetts Route 128, (Cambridge, M. I. T.,, 1958), pp. 66-68.

which have already had experience with suburban location feel they need some form of local public transportation in a new suburban location. This may also suggest that firms migrating from the central area may in a similar manner desire public transportation after they have more experience with a suburban location. The difference in the responses of the two groups of firms is distinct, but the small size of the suburb-to-suburb group makes the interpretation speculative. Firms moving within the central metropolitan area, however, thought public transportation was either important or essential and all expressed satisfaction with public transportation facilities in their new location in the central area. There was no correlation among firms in the central area between per cent of total personnel employed in research and the degree of importance attached to public transportation. (One might expect that, on the basis of a larger sample, a high positive linear correlation would exist between the per cent employed in production and the degree of importance attached to public transportation.)

Responses to the question on the importance of parking facilities in relation to location were inversely related to the responses on the importance of public transportation. Ninety-six per cent of the suburban industrial research firms split evenly in regarding parking facilities as essential or important to their new loca-

tion, in contrast to the unanimous response of unimportant to the question on public transportation. No differences were observed between those who had moved from the central city and those who had moved from another suburb. Suburban industrial research firms were unanimous in their satisfaction with parking facilities at their new location. In contrast to suburban research firms, a relatively larger per cent of firms moving within the central city regarded parking facilities as important, rather than essential. These firms were also not quite unanimous in regard to their satisfaction with parking facilities at their new location. Parking facilities are important to all industrial research firms, but less importance is attached to these facilities by firms moving within the central area. Interviews indicated that the scarcity of parking space, by precluding all but a few, higher echelon professionals and executives from parking at the research facility, increases the firm's dependence on public transportation. Firms chosing a central area location would probably expect that they would not be fully satisfied with parking facilities because of the built-up nature of the area and the high cost of land. These firms therefore consider other factors more important than parking facilities. It is concluded that, for most research firms, the availability of adequate parking space is readily substituted for lack of public transportation in outer ring locations.

Availability of large parcels of cheaper land in the suburbs abets the substitution. Shifts from the center of the city to the suburbs can be readily accomplished because of the widespread ownership of autos at all imcome levels.

Site is an important location consideration in determining which part of a metropolitan area is most suitable for industrial research. A level site is not a prerequisite of research-oriented firms. The compartmentalized character of research laboratories precludes any requirement for continuous process flow which is often responsible for low, single-story structures on level sites. Improved materials handling equipment has made the topography of a site a less formidable deterrant than it once was. The products shipped from research facilities are negligible and the supplies used are small in weight and bulk, making rough topography a less important factor in the choice of a site. Rolling topography may often be preferred, to make buildings more attractive and to add to their prestige value.

Attractiveness of site appears to be an important, but not an essential consideration for research firms in chosing a location within the metropolitan area. Two-thirds of all research firms surveyed thought that attractiveness of site was an important factor. Attractiveness of site was an essential consideration to only a small

per cent of firms located in the suburbs. Firms moving from suburb to suburb appeared to attach less weight to attractiveness than firms moving within the central area and other suburban research firms. No significant difference in the degree of present satisfaction or importance attached to attractiveness was observed between firms in the suburbs and firms in the central area, although firms in the central area were unanimous on the importance of attractive surroundings. Attractive surroundings may be important to research firms because of the prestige such surrounding offer in impressing visitors and because research facilities are likely to be used as a form of institutional advertising.[3] Firms wish to share current positive values associated with science and to take advantage of the ameliorative and connotations implicit in research activity. Sylvania, in announcing proposed construction of a 180-acre, campus-type electronic data processing center in Newton, Massachusetts, claimed that the natural beauty of the wooded site near the Charles River was an important factor in the selection of the site. Attractively landscaped or country-like, campus type settings are preferred, as previously indicated, in order to attract coveted engineers and scientists.

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3 C. E. Mees and J. A. Leermakers, Op. cit., p. 365.

Room for expansion appears to be the most important consideration associated with site in locating a research facility within a metropolitan area. Two-thirds of the research facilities surveyed considered this factor important and one-third considered it essential. In contrast to other site factors, room for expansion was considered essential by a large number of firms and in no instance was a rating of unimportant assigned to this factor. While room for expansion was considered important by firms, whether newly located in the suburbs or in the central area, this factor was considered essential by a relatively larger number of firms in the suburbs than firms in the central area. Firms moving from the central area to the suburbs attached greater importance to expansion than firms moving from suburb to suburb or firms moving within the central area. The relative satisfaction of research facilities with their new sites' capacity for expansion was distinctly greater for firms moving to a new central area location.

Increased business activity is reflected in increased personnel and expanded facilities and is probably the major reason for desiring room for expansion. Rapid growth is a particular characteristic of the research-oriented sector of the economy. The over-all increase in research personnel for all firms in the sample on which data was available was considerably less than the over-all increase in production personnel, indicating that growth in production

in research-oriented industries was in large part responsible for the need for room for expansion. The incomplete information and responses relevant to this data make any conclusions concerning the relative influence of research and production on growth quite tentative. However, it appears that, except for specialized research beanches or centralized research facilities of very large firms, room for expansion is most important to combined research-production facilities. Five years is perhaps too short a time span to permit the drawing of conclusions about the needs for expansion of research facilities. It has been estimated that research laboratories need new buildings or additions every ten to fifteen years.[4] However, this estimate was made without anticipating the tremendous current spurt in the technically-oriented sector of the economy.

The advantages of the suburbs in room for expansion, their relatively cheap land prices and large available parcels of land also operate to give the suburbs an advantage in availability of parking facilities. In fact, much of the large expanse of the suburban site is needed for space-consuming parking facilities. However, in the central, built-up sections of the metropolitan area, assuming that public transportation can be substituted for parking facilities, the required amount of land can be substantially re-

4 C. E. Mees and J. A. Leermakers, Op. cit., p. 365.

duced. This is important in the central city because land prices are considerably higher and large parcels of land are scarce. Even if there is only a partial substitution of modes of transportation in the central area, additional requirements of land for parking for contemplated future expansion is considerably reduced compared to the suburb. However, the persistant increase in the use of the automobile for communing to work is already reducing this particular advantage of the central area.

When land costs are high and land is scarce, as in the central city, the intensity of investment for a given site can be increased by expanding vertically to erect a multi-story building. With no continuous process flow in research, the floor plans of research buildings are arranged on the basis of the laboratory module. The dimensions of the module are determined by the standard dimensions of the particular type of laboratory furniture required. These modules can be added vertically, as well as horizontally. Laboratories requiring large amounts of floor space in one unit are more economical in total cost and walking time if they are multi-storied.[5] Freight elevators are required, even in two story buildings for moving equipment to the upper floors. In buildings of over three floors, both freight and passenger elevators

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5 C. E. Mees and J. A. Leermakers, Op. cit., p. 365.

are justified. When a research building is extended upward over six stories, costs rise considerably because of the increased size of ventilating and air conditioning ducts. In the past, heights of over six stories were considered prohibitive in cost, but with new technological improvements, such heights may no longer prove to be formidable cost problems. It is concluded that vertical expansion of research facilities is a suitable substitute for horizontal expansion in the central or metropolitan areas where land costs are high and large parcels of land are scarce. This increase in intensity of investment is accompanied by rising capital investment in the building as height increases to over six stories. The exact point at which this compensatory increase in capital investment is not justified in terms of the relative advantages of cheap available land in the suburbs, is in part determined by the relative satisfaction of other locational requirements essential for research firms. For instance, if a unique location were available in the central area in immediate proximity to a famous university, the critical capital investment point for the central area might be much higher than ordinarily would be the case.

The relative importance of capital investment to research firms is another factor which may affect venture capital in a central area. Of the whole sample of firms surveyed, a little less than one-half thought that capital

investment was important. Although more firms thought capital investment was important, rather than unimportant or essential, capital investment is not decisively important for the whole sample. Firms moving from central city to suburb were more decisive than any other migrating group in attaching importance to capital investment. In a location decision a firm is less likely to indulge in the more expensive type of intensive expansion in the central area. The indecisive nature of the response of all firms to the relative importance of capital investment is considered significant. Where investment per worker in equipment is high as in research, investment in building costs may be a relatively smaller proportion of total capital cost than is ordinarily the case in other industries. When capital investment is not decisively important, investment in the relatively expensive multi-story research facility in the central area is likely to be economically feasible in relation to the relative advantages of the suburbs for expansion. It is concluded that the substitution of intensity of investment under certain conditions may offer the advantages of the suburbs in providing room for expansion.

Site rental is less decisively important than capital investment as a location factor. Slightly less than half of all the firms in the sample considered site rental as an important factor. Firms in the suburbs responded that

site rental was important, but this was an indecisive response. Firms in the central area attached the highest degree of importance to site rental, but the low degree of satisfaction expressed with site rental in their new location suggests that site rental was relatively unimportant compared to other considerations in the location decision. In fact, the inconclusiveness of the over-all responses to the site rental question, combined with the relatively low satisfaction of all groups of firms with this factor in their new location, suggests that site rental is, indeed, an unimportant factor. The reason for its unimportance can be ascribed to the prevailing high investment per worker in research.

Proximity to other firms was generally an unimportant consideration to firms which moved within the Boston area. Nearness of similar companies was very definitely unimportant to all groups of firms moving within the metropolitan area. Satisfaction with this factor was highest from firms moving from central city to suburb and was lowest for firms moving within the suburbs. The results suggest that sharing prestige with other similar firms conducting research is not a primary motive in the relocation of research firms. Coordination among firms in the same field performing research which complements the research of other firms is either not important or is not limited by distance requirements for physical prox-

imity in communication.

Nearness of suppliers is relatively unimportant as a factor influencing location among research firms which moved within the metropolitan area. Nearness of suppliers, however, is more important than proximity to similar firms. Central area research firms asserted that nearness to suppliers was definitely important, while suburban firms resplied that this factor was definitely unimportant. A comparison of the relative satisfaction of the two groups in regard to this factor indicated that firms which moved from the central city to the suburbs reported a slightly higher satisfaction. Suppliers tend to locate near similar firms to shorten delivery time. An advantage gained from proximity to suppliers is the flexibility provided by rapid communication. The replies indicate that this is relatively more important for the research firm in the central area, but that neither suburbs nor central area have any dearth of proximate suppliers. Assuming that suppliers are more densely located, and therefore more proximate in the central area than they are in the suburbs, it can be concluded that central area firms require more intense communication with suppliers than firms located elsewhere and this is one of several reasons for locating in the central area.

Results of the survey clearly indicate that proximity to technical and scientific institutions is important to all firms moving within a metropolitan area. Firms moving from the central city to the suburbs indicated a high satisfaction with their new location in regard to proximity to institutions, but their satisfaction is this respect was lower than that of any other group moving within the metropolitan area. These results sug= gest, first, that for firms moving to the suburbs, proximity to institutions is sacrificed in favor of other location factors; second, that firms which have moved from the central city to the suburbs, still would prefer to be closer to institutions than their new location permits them to be. It can be inferred further, that if other locational requirements were in some measure satisfied in the central area, the desire for proximity to institutions would result in there being a cluster of firms near institutions located in the central city. These results confirm that communication with institutions is important in decisions to locate within the metropolitan area, but the distance over which such communication can take place is apparently subject to considerable variation.

Prestige value of location was generally rated unimportant. The prestige satisfaction of new locations was generally greater for firms moving from central city

to suburb. There might be some reluctance on the part of firms to give an essential or important rating to a direct question on prestige of location. It is concluded that the suburbs offer higher prestige satisfaction than the central area. Evidence from the survey indicates that prestige is not wholly a function of an attractive site, but is also a function of other psychological factors which were not measured by the questionnaires.

Availability of research personnel was the only factor accorded an essential rating by research firms. There was no difference in the relative satisfaction between suburb and central city. The following is an ordering of the factors which were considered important by research firms: proximity to technical and scientific institutions, attractiveness of site, room for expansion, and parking facilities. The suburbs satisfied the following important factors, listed in order of degree of importance: attractiveness of site, parking facilities, and room for expansion. The central area satisfied one important factor: proximity to technical and scientific institutions, and this factor was accorded the highest degree of importance.

The following factors were denoted as unimportant by research firms, in order from most to least important: nearness of similar firms, public transportation, prestige value of location, and nearness to suppliers.

There was no difference in the satisfaction expressed about the nearness of similar firms, by either respondents in suburb or central city. The suburb satisfied only the one unimportant factor of prestige value of location, while the central area satisfied two unimportant factors: public transportation, and nearness of suppliers. There were two location factors about which respondents were inconclusive: capital investment and site rental. Satisfaction with capital investment was greater in the suburbs, while satisfaction with site rental was greater in the central area.

Three important factors function as referents for the location of research facilities: the transportation network, residential areas of preference for professional personnel, and educational institutions. In the final analysis, two factors must be balanced in locating a research facility in a central area or suburb. The only essential element in the research facilities' locational calculus, availability of research personnel, must be weighed with consideration for the only permanent element in the locational calculus: the educational institution. Compared to other factors analyzed, the educational institution is a permanent structural element in the metropolitan environment. The locus of educational institutions cannot be easily changed unless drastic planning occurs. True, branch campuses, e. g. Lincoln Lab., can occur in

the suburbs, but the most vital part of educational institutions remains heavily committed to a central area location. The significance of the characteristic "important" as ascribed to educational institutions, means that firms can locate over a wider range of distances from educational institutions than they feel they can from the "essential" factor, availability of research personnel. "Essential" as a characteristic ascribed to "availability of research personnel" means that close proximity is desired between place of residence and work, regardless of the diffuse accessibility pattern allowed by the automobile. A study of three different types of research firms located in different sectors and rings of the metropolitan area, indicated that the highest concentration of employment for each firm occurred within one to five miles of the facility. The availability of research personnel, however, is a factor which can be altered by planning. In most industries, the limiting conditions are such that the plan must be adapted to them, e. g. raw material, supply of process water. When a location factor is both an essential and a permanent feature of the environment, location is usually restricted to the specific area. However, as is the case here, when the essential element is relatively temporary and the permanent factor is only "important", the result is a wide range of location choices.

In reference to the Boston metropolitan area, the study indicated that, at the moment, neither the central city nor the outer suburb had the advantage, one over the other, in regard to availability of personnel. In the long run, however, if present trends continue, the availability of research personnel factor will favor the suburb. However, a change in this advantage to the favor of the central area, is readily within the scope of planning. But the location of educational institutions in the central area is a given, limiting condition and cannot be changed by planning. The educational institution limits as a location referent are not as restricting as the limits imposed by the factor "availability of research personnel." Research facilities can locate over a wider range in reference to educational institutions. In the long run, therefore, from the point of view of both the essential and the permanent elements in the locational calculus of research facilities, a central area or outer suburban location are both possible. This is true regardless of the fact that the suburbs are favored by more of the factors considered important to research facilities than the central area. Parking facilities, attractiveness of site, room for expansion, are all factors, like the accessibility of research personnel, which are within the scope of planning. Whether the central area or outer suburb is a good location for a research facility depends on

the effectiveness of planning for either area. If effective and comprehensive planning is carried out on a metropolitan scale, either a central city or an outer suburb location offers certain advantages. For the suburbs, the attractive and innocuous nature of the research facility is in consonance with the residential character of the community and offers a good source of revenue and a balanced tax base. For the central area, the research activity is compatible with other uses already within the area. The compartmentalized nature of research means that it can readily be adapted to a central city site. Systems of movement associated with large shipments of supplies and goods have proved costly and incompatible in the dense built-up sections of the central area, resulting in an out-migration of such activities from the central area. The requirements of research for such activities is very small, making it an excellent possible replacement for the out-migrating activities and a good source of revenue for the central area's declining tax base. Furthermore, the dense, compact central area facilitates face-to-face contact and the communication of ideas.

The strength of various functional linkages from pharmaceutical research to its functionally related institutions should demonstrate how the proposed location of pharmaceutical research would be influenced by the same type of institutions located in the Boston area.

The mileage ranges indicated by pharmaceutical firms surveyed might reflect the longer distances of the larger metropolitan areas in which the firms were located. It is believed, however, that the bias toward larger ranges would not operate in the smallest mileage range of one to five miles. The fact that institutions were used as referents for mileage ranges, rather than the center of the city, might help to obviate possible errors. Over half of the firms responding desired to be within one to five miles of educational institutions from the point of view of professional training and advancement of personnel by participation in conferences and meetings. These were the only decisive responses to the factors listed in the questionnaire. From the point of view of hospital facilities for clinical testing, availability of expert consultants, attractiveness of site, and availability of research personnel, more firms indicated a desire for a one to five mile distance from institutions than any other mileage range offered, but for none of these factors was the choice decisive. It appears that pharmaceutical firms felt that coordination of basic research did not require a proximate one to five mile location and that a location in th e six to ten mile range would suffice just as well. More firms responded that they preferred a location ten to twenty miles from clinical testing facilities than was the case for any other factor. Knowing that Boston's med-

ical schools are all within three miles of the center of the city, then the results indicate that a location in the central area or inner suburbs is functionally preferred for a location in Boston. Preferred functional linkages will be considered in the context of the general locational preferences which pharmaceutical research shares with research in general , especially asthey relate to the distinctive structural elements, important for the location of industrial research facilities in the Boston metropolitan area. It was concluded previously that industrial research facilities could locate in either the central area or suburbs of Boston on the basis of the accessibility to residences of research personnel in both areas. Research facilities might also locate within the relatively wide latitudes deemed appropriate for maintaining contact with educational institutions. It is also concluded that on the same basis, a suitable location for pharmaceutical research in metropolitan Boston would be either the central area or suburbs.

Among the advantages of a central area location would be some functional ties with educational institutions. It can be assumed that some of the more distant linkages indicated by pharmaceutical firms reflect the longer distances made necessary by the very large metropolitan areas in which they are located. It is therefore assumed that pharmaceutical firms would prefer the closer distance

linkages possible in the smaller Boston metropolitan area. Professional pools of labor reside in Boston, Cambridge, and Brookline. For pharmaceutical research good locations in the central area in relation to both the location of educational institutions and residences of professional personnel. First, a location is possible in the northwest sector in Cambridge toward Arlington and Belmont. Second, a location is possible in the southwest sector in an area bounded by the Southeast Expressway to the south, Huntington Avenue to the north and the Fens with Brookline beyond to the west. The southwest location has the advantage of being closer to connections with medical centers and of being nearer the suburb of Brookline which is already a preferred locus for residences of people in the medical profession. The northwest location in Cambridge has the advantage of the prestige conferred by two famous institutions, M. I. T. and Harvard.

A location in the outer suburbs is also possible. In recent years many research facilities have moved to the outer suburbs on or near Route 128. Pharmaceutical firms appeared to prefer suburbs and outer suburbs by name, indicating the favorable impression associated with these portions of the metropolitan area. The number of decisive responses in favor of the central area were only two functional linkages out of a total of seven. The quality of decisive responses was rather weak on this point. An outer

suburban location on or near Route 128 and in or near the established professional communities of Lexington, Wellesley, Weston, and Needham is most favorable in terms of the prestige conferred by Route 128 and the accessibility to professional commuters. The advantages of the suburbs are the availability of attractive open sites which appear to be important to some status-conscious research facilities, and in view of the preference of an increasingly important segment of professional personnel for suburban life.[6] It is therefore the conclusion of this study that pharmaceutical research facilities may locate either in the central city or in the suburbs.

Some general implications have been developed in the course of this study which suggest to planners that there is more to the location of industrial research than has been objectively observed. Industrial research has been studied from the point of view of the scientist and from the point of view of the profit-motivated firm trying to foster more creative and productive research. It is surprising that so little attention has been devoted in such studies to the role of physical environment in fostering more creative and productive research. The

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6 W. H. Whyte, Jr., The Organization Man, (Garden City: Doubleday and Co., 1957), p. 305.

first study of industrial research from a comprehensive point of view was undertaken by a government agency with a planning philosophy, the National Resources Planning Board.[7] The primary viewpoint of their study of industrial research was the welfare of the nation. A pioneer study in its scope, it is the only study of industrial research to concern itself directly with the location of industrial research. However, its treatment of the location of research facilities is cursory.

The present study found that ideas and men are the two most essential components of creative, productive research. Research needs scientists capable of doing exacting, creative work and it is very sensitive to the communication of ideas. At present, the relative scarcity of high-calibre scientists tends to dominate the locational calculus of the industrial research facility. From the point of view of the competitive firm, the most exacting constraint on the location of an otherwise foot-loose or mobile industrial research facility is the necessity for locating in proximity to the residences of scientific personnel. From the broader perspective of the general economic welfare and

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7 National Resources Planning Board, Research-A National Resource, Vol. II, pp. 8-11, (Washington, D. C., U. S. Government Printing Office, 1941).

growth of the nation, it would appear that more emphasis should be placed on the effective utilization of existing professional personnel than on the procurement of additional professional personnel. As has been emphasized previously in this study, there will always be a scarcity of creative scientists. It is therefore doubtful that the competitive position of firms in regard to the unique scientist will be altered if firms continue their present policy of emphasizing the recruitment of run-of-the-mill scientists. If financial rewards for persons engaged in industrial research continue at present or go to higher levels, it is conceivable that the supply of professionals may soon exceed the demand. One way of more effectively utilizing the more ordinary professional is to facilitate the communication of ideas. This emphasis would involve a new set of constraints for the location of research facilities, resulting in a different physical setting.

The physical environment can play an important part in facilitating certain kinds of communication. If recurrent face-to-face contact is the most satisfactory way of communicating ideas, as seems to be the case in research, then physical proximity of similar research firms to institutions would appear to be the best means of facilitating such communication. If experience with other communication-oriented economic activities, such as segments of the garment and financial industries, may

be taken as a precedent, it would be surprising to find that research does not share the same requirements for dense, central city locations. All such activities appear to be unstandardized and quality-centered, requiring face=to-face contact. One reason for the disparity in location requirements might be that the exact nature of face-to-face contact in research activities differs in several respects from the type of face-to-face communication required in the communication-oriented segments of the garment and financial industries. This disparity seems to suggest that the present concept of face-to-face contact is as yet too loose and vague to justify a central city location for all types of economic activity. A model of face-to-face communication must be developed, using criteria which would sharply differentiate various types of personal communication and consequently reflect different locational requirements.

Because an industry is most often found associated with a particular location does not mean that that location is the most desirable or necessary. The value of conducting such a study as this is that it helps the planner guard against unwarrented assumptions. The planner, with his special knowledge of the physical structure of the urban environment and his broad perspective of the welfare of industry as a whole, can bring to the fore new ways of satisfying the functional requirements

of an industry which might be overlooked from the narrower viewpoint of the individual competing firm. For both planners and industrialists, a location of a research facility connotes low, sleek, buildings in a country-like atmosphere. The misconception of the scientist performing painstaking experiments isolated from the world is implicit in this rural image. The fertile, creative atmosphere found in many universities is not generated by the rural appearance that so many college campuses happen to enjoy, but rather, it is the result of active communication within the academic community. It is the stimulating exchange of ideas that is more likely to foster creative, productive research. It is unlikely, therefore, that industrial research firms will encourage productive research by superficial imitation of the rural characteristics of many university campuses. Such an argument merits careful consideration before a research facility decides on a location in the isolated portion of the urban fringe.

The claim often made that a rural environment for a reasearch facility will confer an academic atmosphere is not the real advantage for such a location. The real advantage appears to be its ability to attract the relatively scarce scientists. Planners should note that

the importance of leisure time activities, cultural, recreational and living conditions suggest that such activities, often relegated to a secondary role as "services" in economic base theory, may become a primary resource in attracting the more numerous research facilities of the future. It is also suggested that in locating research facilities a careful balance must be maintained between the importance of leisure time activities in procuring scarce professional personnel and the functional necessity of communicating ideas for creative, productive research. The importance of leisure activities in attracting research-oriented industries has another important implication for planning. Under these conditions, the long-advocated, integrated and comprehensive approach to urban planning becomes more a pragmatic necessity than the airy dream it may have been in the past. All types of land uses, industrial, residential and recreational must be carefully balanced for the economic benefit of the metropolitan community.

The present study found that research facilities of certain types seemed to be ambivalent in their location requirements. An ambivalent activity, in this sense, is one which can locate either in the central city or in the suburbs. There are several reasons for such ambivalence in the technically oriented sector of the economy. For example, contacts may be made over wider distances since

the advent of the automobile. Also, there are alternative solutions available for that most essential constraint in the location of research facilities, proximity to residences suitable for professional personnel. Furthermore, this constraint itself is not a permanent feature of the environment but may be changed either by natural forces or by planning. There advantages to this ambivalence for the planner: it allows him increased flexibility in guiding the fulfillment of the different needs of various parts of the metropolitan area. Research facilities can help alter the declining tax base of the central areas, for example, and they are also compatible neighbors to residential suburbs. This ambivalence, convenient as it may seem, deprives the locational calculus of its proper emphasis on the communication of ideas. If this emphasis were restored to its essential primacy, it would put additional constraint on the location of research facilities. Possibly it is time for research facilities to pay more attention to the role that the metropolitan area can play in facilitating the communication of ideas.

A P P E N D I C E S

DEFINITIONS OF TERMS USED IN APPENDICES

LOCATION QUOTIENT: This gives the degree of concentration of a particular industry in a specific region. It is obtained by dividing the % of the national total of the particular industry to be found in that region by the % of all industry in that region.

Coefficient of Localization: This gives a picture of the degree of local concentration of a particular industry as compared to the distribution of the working population as a whole. It is the sum (divided by 100) of the plus deviations of the regional percentages of all workers in all industry. Complete local coincidence of the industry with all industry gives a coefficient of zero; complete differentiation gives a figure approaching 1.

Coefficient of Linkage: This measures the location of a particular industry compared to that of another. It is the sum (divided by 100 and subtracted from unity) of the plus deviations of the regional percentages of all workers in the particular industry from the corresponding regional percentages of all workers in the other industry.

SOURCES: P. S. Florence, "The Selection of Industries Suitable for Dispersion Into Rural Areas," Journal of the Royal Statistical Society, vol. cvii, pt. 2, 1944, pp. 93-107.

P. S. Florence and W. Baldamus, Investment Location and Size of Plant, (Cambridge: The University Press, 1948), pp. 34-88.

National Research Council, Industrial Research Laboratories of the U. S., 10th ed., 1956.

U. S. Dept. of Commerce, U. S. Bureau of the Census, 1955 Census of Manufacturers, Vol. II.

APPENDIX A

Gentlemen:

A study is being made of the factors affecting the location of industrial research facilities in the metropolitan area. According to my records, within the last five years you have either moved your research facility or established a new one. Answers to the questions on the enclosed questionnaire will be used as illustrative statistical material for a Master's thesis which I am preparing for the Department of City and Regional Planning, Massachusetts Institute of Technology.

No identification by company or person will be made in the use of this material. It is hoped that the information derived from the answers to the questionnaires will be of benefit both to city planners and to the managements of companies doing industrial research.

Your courtesy in replying promptly, using the self-addressed, stamped envelope which I have enclosed with the questionnaire, will be greatly appreciated. If you should wish to make any additional comments on matters not specifically covered by the questions, please feel free to do so.

Very truly yours,

/a

Burton Goldberg

APPENDIX A

QUESTIONNAIRE

1. How would you rate the Boston Metropolitan Area on:

	EXCELLENT	GOOD	FAIR	POOR
a. availability of scientific and skilled personnel:				
b. personal & corporate taxes:				
c. availability of attractive living accomodations and environment:				
d. cultural facilities:				
e. availability of educational institutions:				

Please turn to page 2

2.

A. How important are the folowing factors in your consideration of a location?

B. Which of the factors listed under A does your present location satisfy?

	ESSENTIAL	IMPORTANT	RELATIVELY UNIMPORTANT
a. accessibility of research personnel:			
b. parking facilities:			
c. public transportation:			
d. proximity to technical and scientific institutions:			
e. attractiveness of site:			
f. nearness of similar companies:			
g. prestige value of location:			
h. nearness to your suppliers:			
i. room for expansion:			
j. site rental:			
k. capital investment:			

3. What other locations were considered before you decided to move to your present site?

4. Basic data.

   a. Number of persons employed in Industrial Research*

      (1) Professional:

      (2) Technical:

      (3) Administrative & support: _____

      TOTAL:

*Meaning a separate, permanently established research staff engaged in research, development or product improvement. Do not include teams temporarily recruited for the purpose or assembled from operating staff.

5. If you care to make any comments on the questions above or on any matters not covered by the above questions, your remarks will be greatly appreciated.

APPENDIX B

Gentlemen:

A study is being made of the factors affecting the location of pharmaceutical research facilities. Answers to the questions on the enclosed questionnaire will be used as illustrative statistical material for a Master's thesis which I am preparing for the Department of City and Regional Planning, Massachusetts Institute of Technology.

No identification by company or person will be made is the use of this material. It is hoped that the information derived from the answers to the questionnaires will be of benefit both to city planners and to the managements of companies doing pharmaceutical research.

Your courtesy in replying promptly, using the self-addressed, stamped envelope which I have enclosed with the questionnaire, will be greatly appreciated. If you should wish to make any additional comments on matters not specifically covered by the questions, please feel free to do so.

Very truly yours,

/a

Burton Goldberg

APPENDIX B

QUESTIONNAIRE

	1 to 5	6 to 10	10 to 20	over 20
1. Within which mileage range of hospital facilities necessary for clinical testing would you prefer to locate your research facility?				

2. Within which mileage range of educational institutions, from the point of view of:

a. availability of professional personnel?	
b. coordination of basic research?	
c. availability of expert consultation?	
d. professional training and advancement for your personnel?	
e. participation in professional conferences and meetings?	
f. attractiveness of site?	

3. Within which mileage range do you find that your professional personnel prefer to live?

4. Within which mileage range do you find that your technical and administrative personnel prefer to live?

5. Which of the following types of research and development activity would you be most likely to: A- separate entirely, or, B- locate in the immediate proximity of, your production facilities?	A separate	B locate near
a. research on fundamental problems without any particular intended application:		
b. background applied research, research increasing the store of knowledge on which future applications can draw:		
c. product directed or process research, research intended to yield a product or process of a given commercial character:		
d. development, application of the store of existing knowledge to particular commercial circumstances:		

¢.

6. Considering all the above factors, check that portion of the metropolitan area which you feel presently satisfies your needs:	core	inner ring	suburbs	outside metro. area
a. if you were to locate a separate research facility:				
b. if you were to locate a research facility in combination with a manufacturing facility:				

APPENDIX C

COMPARISON OF EMPLOYMENT COMPOSITION:

PHARMACEUTICAL RESEARCH & INDUSTRIAL RESEARCH

	% OF TOTAL EMPLOYMENT	
	Pharmaceutical Research (United States)	Industrial Research (Boston)
Engineers	4.3	25.
Technical administrative	3.5	2.4
Other technical	14.0	28.6
Chemists	25.5	5.9
Biologists	10.4	.4
Physicists	-	2.9
Mathematicians	-	6.3
Pharmacists & pharmacologists	1.4	-
Bacteriologists	.5	-
Other professionals	.7	1.04

APPENDIX D

Table D-1: Location Coefficient for Pharmaceutical Industry.

Region	% of all mfg. employment in 1954	% of pharm. employment in 1954	Deviation from total
New England	9.1	3.3	-5.8
Middle Atlantic	26.	45.6	+19.6
East North Central	28.4	37.	+8.6
West North Central	5.9	4.9	-1.
South Atlantic	11.1	2.9	-8.2
East South Central	4.5	2.6	-1.9
West South Central	4.5	.6	-3.9
Mountain	1.2	.1	-1.1
Pacific	8.6	2.7	-26.8
		Total plus deviation	28.2

Location coefficient for pharm. industry: .282

APPENDIX D - Cont'd.

Table D-2: Location Coefficient and Coefficient of Linkage for Pharmaceutical Research.

Region	% of all pharm. research employment.	deviation from % of all pharm. employm't.	deviation from % of all mfg. employm't.
New England	2.2	-1.1	-6.9
Middle Atlantic	59.	+13.4	+3.3
East North Central	32.1	-4.9	+3.7
West North Central	1.9	-3.9	-4.
South Atlantic	.2	- .9	-10.9
East South Central	.7	-1.9	-3.8
West South Central	.2	- .4	-4.1
Mountain	--	--	-1.2
Pacific	3.3	+ .6	-8.
		+14.	-38.9 +36.7

Pharmaceutical research: Location coefficient: = .37

Coefficient of linkage with pharmaceutical production: = .86

$(1 - \frac{14}{100} = .86)$

APPENDIX D - Cont'd.

Table D-3: Pharmaceutical Research Location Quotient for Various Metropolitan Areas.

Standard Metropolitan Area	% employed mfg. employment, 1954	% employed pharm. research, 1955	Location Quotient
Boston	1.78	.2	.112
Chicago	6.1	6.6	1.1
Detroit	3.65	4.3	1.2
Indianapolis	.64	10.5	16.4
Kalamazoo	.02	8.9	445.
New York-New Jersey	11.4	28.7	2.51
Philadelphia	3.5	10.5	3.
SanFrancisco - Oakland	1.15	.3	.26
Los Angeles-Long Beach	4.0	1.9	.48

APPENDIX E

Comparison of Boston, New York, Philadelphia: Number of Students Enrolled in Specialties Related to Pharmaceutical Research.

Table E-1: Pharmaceutical Research - Related Education.

	Undergraduate Medical School		Pharm. School		Graduate Med. School		Univ. Biol.-Chem.	
	Total No.	Index	Total No.	Index	Total No.	Index	Total No.	Index.
BOSTON	1250	100	750	100	86	100	686	100
NEW YORK	2384	.37	1385	.37	185	.43	1878	.55
PHILADELPHIA	2081	110	1053	.93	68	.52	739	.72

APPENDIX E - Cont'd.

Table E-2: General Educational Facilities.

UNIVERSITIES

	Undergraduate		Graduate (Phys. Sciences)	
	Total No.	Index	Total No.	Index
BOSTON	81,720	100	2551	100
NEW YORK	119,745	.29	5627	.45
PHILA.			2118	.55

APPENDIX F

RESULTS OF SURVEY OF PHARMACEUTICAL FIRMS

Table F-1: Linkages of Pharmaceutical Research With Institutions in a Metropolitan Area.

Functional Linkages	Preferred mileage zones - % of Firms				
	1 - 5	6 - 10	10 - 20	Over 20	Not Significant
Hospital facilities					
clinical testing	35.3	5.9	29.4	-	29.4
Educational institutions					
avail. of resch. pers.	35.3	11.8	11.8	-	41.2
coordination of basic research	25.	25.	12.5	-	37.5
avail. exp. consult.	41.2	17.6	11.8	-	29.4
prof. train. & adv.	53.	35.3	11.8	-	-
partc. in conf.	53.	17.6	11.8	5.9	11.8
attract. of site	37.5	7.5	7.5	7.5	5.
Trip to work					
profess. personnel	23.5	41.2	29.4	5.9	
admin. & technical	23.5	41.2	23.5	11.8	

APPENDIX F - Cont'd.

Table F-2: % of Firms Favoring Separate or Proximate Research Facilities With Reference to Production.

TYPE OF RESEARCH	SEPARATE	LOCATE NEAR
Fundamental	70	30
Backgraound applied	50	50
Product- or process-directed	6	94
Development	-	100

APPENDIX G

RESULTS OF SURVEY OF INDUSTRIAL RESEARCH FIRMS MOVING WITHIN THE BOSTON METROPOLITAN AREA, 1955 - 1960.

Table G-1: Rating of Location Factors by Location of Firm, By Per Cent of Sample

	ALL FIRMS			
accessibility of research personnel. . .	essential 54	important 42	unimportant 6	satisfied in present loc. 100
parking	42	54	-	96
public trans.	12	24	66	60
proximity to institutions	24	72	6	96
attractiveness of site	12	66	24	84
proximity to similar co's.	6	12	84	78
prestige value	6	30	66	66
proximity to suppliers	-	48	54	48
room for expansion	36	54	18	78
site rental	6	48	42	48
capital investment	24	48	30	60

APPENDIX G - Cont'd.

Table G-1, cont'd. Rating of Location Factors by Location of Firm, By Per Cent of Sample.

SUBURBAN FIRMS

	essential	important	unimportant	satisfied in present loc.
accessibility of research personnel	69.3	53.9	7.7	100
parking	46.2	46.2	7.7	100
public trans.	-	15.4	84.7	46.2
proximity to institutions	30.8	69.3	-	92.4
attractiveness of site	15.4	53.9	30.8	92.4
proximity to similar co's.	7.7	15.4	77	77
prestige value	7.7	30.8	61.6	69.3
proximity to suppliers	-	38.5	61.6	46.2
room for expansion	38.5	61.6	-	84.7
site rental	8.3	41.7	50	46.2
capital investment	23.1	46.2	30.8	61.6

APPENDIX G - Cont'd.

Table G-1, Cont'd. Rating of Location Factors by Location of Firm, By Per Cent of Sample.

CENTRAL AREA FIRMS

	essential	important	unimportant	satisfied in present loc.
accessibility of research personnel	-	100	-	100
parking	25	75	-	75
public trans.	50	50	-	100
proximity to institutions	-	75	25	100
attractiveness of site	-	100	-	75
proximity to similar co's.	-	-	100	75
prestige value	-	50	50	50
proximity to suppliers	-	75	25	55
room for expansion	25	75	-	50
site rental	-	75	25	50
capital invest.	25	50	25	50

APPENDIX G - Cont'd.

Table G-2: Rating of Location Factors By Kinds of Movements Made By Firms.

Movement: Central City To Suburb	essential	important	unimportant	satisfied in present loc.
accessibility of research personnel	55	33	11	100
parking	44	44	11	100
public trans.	-	-	99	33
proximity to institutions	33	66	-	88
attractiveness of site	22	44	33	88
proximity to similar co's.	11	11	77	88
prestige value	11	22	66	66
proximity to suppliers	-	44	55	55
room for expansion	44	55	-	77
site rental	11	33	44	44
capital investment	22	55	22	55

APPENDIX G - Cont'd.

Table G-2, Cont'd.: Rating By Location Factors By Kinds of Movements Made By Firms.

Movement: Suburb to Suburb

	essential	important	unimportant	satisfied in present loc.
accessibility of research personnel	25	75	-	100
parking	50	50	-	100
public trans.	50	50	-	75
proximity to institutions	-	50	50	100
attractiveness of site	-	75	25	100
proximity to similar co's.	-	25	75	25
prestige value	-	50	50	50
proximity to suppliers	-	50	50	-
room for expansion	25	75	-	100
site rental	-	50	50	50
capital investment	-	50	50	75

APPENDIX G - Cont'd,

Table G-3: Rating of the Boston Metropolitan Area by Industrial Research Firms Which Have Moved Within The Boston Area In The Last Five Years.

	R A T I N G S			
Characteristics	excellent	good	fair	poor
availability of scientific & skilled personnel	65	35	-	-
personal and corporate taxes	-	6	47	47
availability of attractive living accomodations & environment	76	18	6	-
cultural facilities	94	6	-	-
availability of educational institutions	100	-	-	-

APPENDIX H

Table H-1: Distribution of Industrial Research Employees by Place of Work - 1955

	SECTORS							
	N. E.	N.	N. W.	W.	S. W.	S.	S. E.	TOTAL
central city	38	94	2845	48	1708	-	-	4733
inner sub.	30	69	166	1008	45	-	47	1365
middle suburb	199	20	35	248	117	-	12	631
outer suburb	790	-	291	112	92	-	-	1285
fringe	35	22	8	-	82	-	21	169
TOTAL	1092	205	3345	1416	2065	-	80	8184

Towns and cities with largest number of employees:

Beverly
Salem
Everett
Cambridge
Concord
Boston
Norwood
Waltham
Needham
Watertown
Newton

SOURCE: New England Directory of Manufacturers, 1960

APPENDIX H - Cont'd.

Table H-2: Distribution of Engineers and Chemists by Place of Residence.

	SECTORS							
	N. E.	N.	N. W.	W.	S. W.	S.	S. E.	TOTAL
central city	11	10	364	71	399	-	-	855
inner suburb	46	83	260	155	10	29	34	617
middle suburb	90	61	90	140	42	2	46	471
outer suburb	35	8	38	84	37	12	10	222
fringe	26	56	32	3	1	-	13	131
TOTAL	208	218	784	453	489	43	103	2296

Towns and cities with largest number of residents:

Marblehead
Lynn
Melrose
Boston
Quincy
Cambridge
Belmont
Arlington
Lexington
Winchester
Brookline
Newton
Wellesley
Weston
Needham
Wayland

SOURCE: Who's Who In Engineering; Directory of the Northeastern Chapter of the American Chemical Society, 1953.

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