

# Haskins Laboratories

305 East 43rd Street  
New York 17, New York

HASKINS LABORATORIES were founded in 1935 and incorporated in the State of New York in 1937.

The purpose for which they were founded was:

*“The establishment and operation of laboratories for the sole purpose of scientific and educational investigations, the knowledge obtained to be used, without profit, to advance the frontiers of knowledge and to alleviate human suffering.”*

The purpose of the Laboratories is research — research in certain new and frontier fields requiring the collaboration of established disciplines.

The Laboratories were certified by the New York State Board of Regents as a teaching and research institution at university level, and were granted tax exempt status by letter from the Commissioner of Internal Revenue dated October 18, 1940.

# HASKINS LABORATORIES

1953

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### *Directors*

FRANKLIN S. COOPER  
HENRY R. GUILD  
EDNA F. HASKINS  
CARYL P. HASKINS  
JAMES N. WHITE

### *Officers*

CARYL P. HASKINS

*President*

JAMES N. WHITE

*Vice President*

PAUL A. ZAHL

*Secretary*

FRANKLIN S. COOPER

*Treasurer*

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## What Is Haskins Laboratories?

HASKINS LABORATORIES is a non-profit educational institution for basic research and research training in certain pioneer areas which involve several scientific disciplines. For the past eighteen years, it has carried on its work in a few selected frontier fields. It has sought to pioneer in these and to advance them vigorously in the hope that they might become significant and generally accepted "growing points" of research knowledge. When this has occurred, the Laboratories have sought new areas to pioneer in the same way, taking as their principal function the initiation and proving of profitable new areas of research rather than their continued exploitation once they have become more generally recognized. Consistent with this objective, the Laboratories have maintained considerable flexibility of approach, altering in focus from time to time as older fields of effort became better known and more widely accepted and newer and therefore less familiar and more potentially challenging opportunities appeared. They have thus assumed the role of the "uncommitted investigator." Over the years the research program of the Laboratories has had primarily conceptual rather than operational goals.

If an unorthodox pattern of approach of this sort is to be successful, two aspects of organization are exceedingly important — flexibility and freedom in research, and extremely close cooperation, sympathy and understanding among scientists trained in several apparently quite different disciplines. The research approach to any problem must stress the basic unity of knowledge.

Particular effort is made to meet both of these rather exacting requirements in the Laboratories. The organization is specifically designed to permit maximum freedom and flexibility in work. The total staff numbers only about forty. Small in size and highly flexible in operation, it is

free to devote its entire attention to research and instruction, and can bring its joint effort to bear on critical problems. There is much emphasis on wide and continuous exchange of information with other scientists in related fields. Joint research projects with other institutions and the training of promising young scientists in techniques and approaches developed in the Laboratory are an important part of its life. The Laboratories have been active in the training of research students. Thus students whose research was conducted entirely or in part in the Laboratories have received or are preparing for doctoral, masters, or undergraduate degrees in a number of institutions both in the New York area and more widely afield, notably at Harvard University, the Massachusetts Institute of Technology, Columbia University, Union College, New York University, and the College of the City of New York.

The Laboratories were established in 1935 and were incorporated in the State of New York on May 5, 1937. They were certified as a scientific and educational teaching and research institution by the Board of Regents of the State of New York, and were granted tax-exempt status by letter from the Commissioner of Internal Revenue dated October 18, 1940. They are affiliated with Union College at Schenectady, New York, where the director is Research Professor.

The Laboratories are supported by funds from several sources. Basic continuing support is provided by funds privately contributed. In addition, grants in aid of research programs have been or are being received from the Carnegie Corporation of New York, the Rockefeller Foundation, the Loomis Foundation, the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, the American Cancer Society, and similar bodies. In addition, the Laboratories have held government contracts for research work (at cost) and received grants in aid for research from certain private corporations. Its entire effort and expenditure has been for scientific re-

search and training in research; all research findings not classified by the government are published and circulated as promptly as possible. Research expenditures to date amount to roughly \$1,500,000.

To the granting agencies and individuals without whose understanding and aid a large part of the work would not have been possible, the staff of the Laboratories expresses deep appreciation, and especially for the confidence placed in them, and the encouragement given their endeavors.

### Research on Speech and Auditory Perception

A MAJOR RESEARCH PROGRAM in the laboratory is a study of the exact nature of the phenomena involved in verbal communication. The range of these phenomena is extremely diverse. A consideration of speech in inter-personal exchanges from one person to another as well as in the communication of ideas by mass media, special pleadings, and entertainment indicates its extraordinary variety and importance. The spoken message conveys not only the words of the speaker — the minimal content which would be given by the same message in writing — but additional information about the personality, the mood, and the sincerity and intent of the words of the speaker. Yet, a minimum requirement must always be that the speech shall be intelligible. It is to an understanding of the acoustic and perceptual factors responsible for speech intelligibility that this research program is, in large part, now directed.

The problem is basically a psychological one, involving the perception of complex auditory patterns and the identification of acoustic cues with the linguistic elements of the message. This research has required the construction of two unique instruments: one is a special-purpose sound spectrograph which can convert spoken words into "picture" transparencies of the words; the other is a pattern playback which can re-convert these pictures — and simpler, hand-painted ones — into sounds like speech. With these instru-

ments and the research techniques they make possible, a team of psychologists, linguists, and engineers has been engaged for the past several years in a study of speech in its various aspects: acoustic, perceptual, and linguistic.

Although speech may at times appear to flow along as a continuous series of sounds, it can be analyzed by linguistic methods into a sequence of elementary units or phonemes. There are about forty of these in American English. In general, it is tacitly assumed that these same entities are the units of auditory perception but when an attempt is made to find the acoustic patterns which correspond to the linguist's phonemes, the problem becomes rather involved. Even the pictorial representation of speech sounds provided by the sound spectrograph fails to give a simple and unambiguous answer.

The research rationale which was developed to study the perceptual phenomena depends upon the conversion of spectrographic patterns into speech, not only in their original form, but also after intentional modifications and simplifications. For example, the playback has been used to produce synthetic speech both from direct spectrograms and from drastically simplified patterns of the same sentences; the two synthetic versions were about equally intelligible to the listener. In a similar way, a series of designs — quite literally hand-painted to represent hypotheses about those acoustic factors which were thought to be most important for perception — were converted into the corresponding sounds by the playback and their resemblance to the patterns of spoken words judged by ear.

Although the hand-painted sentences were very considerably simplified as compared with spoken sounds, the paintings were nevertheless copied from actual spectrograms of connected text. Each painted sound was a special case in the sense that it was modified (drastically, in some cases) by the other phonemes which happened to be next to it. It seemed desirable to study the individual phonemes more systematically and in all of their usual combinations with

other phonemes. A necessary first step was to find good representations for the vowels. Professor Delattre\* has carried through a very thorough study of the cardinal vowels of the International Phonetic Association and has established a set of frequency values by which the entire range of vowels can be reproduced with only two formants for each vowel, i.e. two horizontal brush strokes on painted spectrograms.

A class of sounds which has always been rather puzzling and which does not show well on spectrograms is the stop consonants. The first step in a study of these sounds was to explore, by cut-and-try methods, all of the variables which seemed to be involved, their relative importance, and the range of variation. Next, as one of the most important variables, the location along the frequency axis of the burst of noise, or "explosion," with which a syllable such as *pa* or *ta* or *ka* commences was selected. Recordings were made of a large number of synthetic "syllables" in which all possible frequency positions for the explosion were paired with each of the more common vowels. By thus systematically covering all possibilities and presenting the syllables to a group of listeners, it was possible to determine the acceptable combinations. In fact, there was a high degree of agreement among the listeners in identifying certain combinations. In this way, an unambiguous description of one important feature of the stop consonants was obtained. An additional and most interesting conclusion from the experiment was that the syllable rather than the phoneme is the irreducible unit for perception, at least for this group of sounds.

Another variable, obviously important for the stop consonants and for other sounds as well, is the transition from consonant to steady-state vowel. On spectrograms, the vowel formants bend sharply upward or downward where vowel and consonant join. From the earliest painted sentences it appeared that these transitions could not be ignored. Hence, the next step in specifying the stop consonants was

\* University of Pennsylvania and Haskins Laboratories.

to explore the effect of transitions, either with or without initial explosions. A further systematic test was made, somewhat like that described above, employing all possible transitions alone and in combination with initial explosions. These also are heard as highly identifiable syllables. With still another group of sounds, the resonants, transitions are the principal acoustic cues and syllables have been architected with the resonant consonants just as with the stop consonants. These experiments have demonstrated quite conclusively that the transitions seen in spectrograms are not merely incidental — or even confusing — aspects of the speech sounds but constitute in fact some of the major cues on which intelligibility depends. This is a point which could only have been established by synthetic methods and serves to illustrate the power and flexibility of this approach.

The results of these and other experiments with the individual sounds of speech and with simple syllables have yielded rules for the synthesis of words and sentences. Some attempts at completely synthetic speech of this kind have been made, resulting in sentences which are highly intelligible, although somewhat unlike spoken English in stress and timing.

Exploratory studies have been made of speech in competition with noise and with other speech. With a single verbal communication, in quiet or noise, intelligibility is of principal interest. When two or more spoken messages are presented simultaneously, there is competition for attention. Interfering signals are resolved, if at all, by factors that make for attention and guide the listener in following one message or the other. These factors do not appear to be the same as those affecting intelligibility.

Another of the studies which is in progress deals with the psychological basis of the research procedure. Experiments show that auditory and visual patterns are inter-convertible in such a way that simplification of one pattern, (the visual pattern of speech), does not seriously affect the other pattern, (the speech as heard). This suggests an underlying

mechanism of considerable generality: if perceptual processes operate on organized stimulus data, that is, on patterned information, and if there is close similarity between the perceptual processes of vision and audition, then there should be an optimum way of organizing auditory stimuli. And there should be a relationship at the stimulus level — an audio-visual transform — for converting acoustic data *by formula* into optical data (and conversely) with the greatest retention of the “structure” of the auditory and visual patterns. This is not based on any assumption that vision and audition are interchangeable, but implies only that there is a best way to transform stimulus data from one modality to the other. The sound-spectrogram appears to be a moderately good approximation to such an ideal audio-visual transform.

General principles relating audible and visible patterns must, of course, be assumed to operate in the case of speech as well as for other sounds. But for speech there is the additional possibility that it is listened to not merely as a series of sounds but as audible gestures which can be mimicked to check the accuracy of reproduction. Sometimes pairs of speech sounds are very similar acoustically even though the articulatory gestures required to produce them are very different. (The voiceless stop consonants are of this sort.) It is simpler to account for the ability to distinguish between such sounds if it is assumed that the perceptual processes involve the fairly gross differences in articulation rather than the seemingly smaller differences in the sound patterns. A “motor theory” along these general lines is not wholly new but has until now remained largely speculative. Clear evidence supporting such an explanation has been obtained from systematic experiments on the stop consonants. A “feedback” hypothesis of this kind is, in any case, a most useful working tool.

Since the methods are applicable in a number of fields, talks have been given before various groups of linguists, phoneticians, psychologists and others interested in speech

communication to describe the novel approach and technique which has been found useful in this laboratory. A number of scientific papers have been presented orally and accompanied by demonstrations of painted spectrograms and the sounds which correspond to them; other papers have been published in journals in the fields of linguistics, psychology, and acoustics. A number of people professionally interested in the work have visited the laboratory, and collaborative efforts with other workers have had an important part in the research program.

Substantial progress has been made toward an understanding of the acoustic counterparts of the basic linguistic units of speech. These results have been presented to a number of colleagues, with several of whom there has been active collaboration. Work on speech is a major area of interest, in part because speech patterns are interesting in themselves but principally because of the immense social significance of communication by the spoken word, particularly in the newer forms of mass communication. A precise acoustic specification of the phonemes of American English is one aim. Non-speech sounds are being studied partly to clarify speech problems and partly to gain further insight into relationships between audible and visible patterns; this deserves even more attention. Other areas which are promising are the more subtle aspects of speech involved in intonation, stress, voice personality, and cues to the speaker's frame of mind. An understanding of these aspects of speech is quite as important for the effective use of mass methods of communication as are the engineering developments which have thus far constituted the bulk of research in communications.

### Physiology

ONE OF THE EARLIEST research programs in the laboratory relates to problems of physiology and growth. Earlier phases of this program dealt with the effects of radiant energy (x-rays, focussed electrons and protons, slow and

fast neutrons,) on normal and, later, on malignant tissues.

This led to a general program of basic research in cancer biology. The cancer problem was attacked from a variety of aspects: pharmacological, endocrinological, and biochemical. One study, for example, dealt with the effect of pharmacologically induced estrus-suppression on the incidence and development of spontaneous mammary carcinomas in mice. Another dealt with the cytology of tumor growth and the localization of various dyes and neutron-capturing materials in tumor tissue. Current investigation deals with shifts within the body of nucleotide levels. Significant differences, as a function of tumor growth, have been observed in blood and tissue adenosine triphosphate. These differences suggest clues about the role of the vital energy-bearing adenosine polyphosphates in growth and pathogenesis.

An aspect of physiology relating to the cancer problem which has been vigorously pursued deals with the effect of certain bacterial toxins on tumors. The results of these studies have as yet had little immediate practical value, but certain generalizations have emerged, a principal one being that virtually all gram-negative bacteria contain a type of toxin which, injected into tumor-bearing animals, produces hemorrhage within the tumor. The hemorrhagic effect is a definitive one, and on the basis of hemorrhage-inducing characteristics, all bacterial species seem to fall into either of two classes: those that do and those that do not contain the hemorrhage factor. It is of great interest that these two groups correspond almost completely with the classical gram-negative and gram-positive groupings based solely on staining affinities.

A further general field of interest is the effect on cell proliferation of certain toxic organic substances found in nature. A survey is currently underway to investigate growth-inhibiting possibilities of various biochemical fractions derived from marine organisms.



## Microbiology, (Protistology), and Nutrition

AMONG MICROORGANISMS, protozoa include those most animal-like (as their name indicates). They are nearly all motile and many ingest food particles. One of the most important things one can learn from them is how their various foodstuffs are converted into fuel and nutritional building blocks. They thus serve to illumine the biochemical processes shared by all animals, including man. They may be used as models for working out fundamental metabolic pathways and, in a more restricted way, as analytical tools.

Many of the problems encountered in the nutrition of the intact animal or of its component cells in tissue culture are extremely complex. But a great deal has been learned about animal nutrition from research directed at the growth requirements of microorganisms. This approach has the great advantage that one can start with an organism having simple requirements and can then progress stepwise in nutritional complexity by a proper choice of assay organisms. This is the approach employed in the laboratory for the past ten years. Earlier work on inorganic requirements was followed by an intensive study of the more complex requirements of the photosynthetic purple bacteria and of various algae and protozoa.

The work on microbial nutrition at Haskins Laboratories has been focussed on uncovering key reactions and metabolites in cellular processes, and has, as is to be anticipated in any rapidly developing field, undergone continuous change in emphasis. The development of analytical methods for new vitamins and for components of nucleic acids is proceeding with gratifying speed. This work also involves the development of practical culture media for types of photosynthetic organisms new to the laboratory and likely to prove valuable in studies of photosynthesis.

Assay methods have been developed including the widely used *Euglena* assay for vitamin B<sub>12</sub>. At present, studies are

being made of protozoa which ingest particulate foods since these may be ideal assay organisms for vitamins in bound form and for high molecular weight compounds in general. The chryomonad method for assay of vitamin B<sub>12</sub> is entering into wide use. It may be possible in this way and with a variety of organisms eventually to provide media for tissue culture which are completely defined chemically.

While the aim of the group in microbiology is to develop protistan tools for attacking fundamental biochemical problems, the more specific goal is to make the growth of cell cultures as simple technically as that of hardy microorganisms. A simple cell culture technique based on chemically defined culture media would allow the direct identification of the regulators of growth, i.e. the hormones, and would also allow identification of the specialized growth requirements of the different kinds of cells composing the animal body.

To attain this somewhat remote-appearing end, some obstacles to mammalian cell culture have been categorized and appropriate microbiological investigations have been initiated, thus in effect converting a multi-variable problem into a series of simpler problems more amenable to experiment. The principal obstacles, and the corresponding microbiological investigations, are as follows:

A. *Inorganic requirements.* The intact body appears to utilize chelating agents such as citrate as a means of mobilizing metals tending to form precipitates with such biologically important ions as phosphate and bicarbonate. Consequently an intensive study has been in progress on the use of metabolizable and non-metabolizable chelating agents in compounding culture media. Much of this work has been published.

B. *Vitamins.* When these studies were initiated, there were obviously vitamins still to be identified which were required by intact animals. It was logical to suppose that these vitamins would also be needed by isolated cells and

tissues. In the hope of speeding the identification and thus enhancing the availability of these vitamins to cell cultures, a wide variety of protists requiring growth factors were and are being investigated. The *Euglena* and chrysoomonad assays for vitamin B<sub>12</sub> represent one fruit of this program. Reports on ciliates, hemoflagellates, and *Pernanema* (a predacious euglenid) have already been published or are in press; several other organisms are in the "development" stage. The hemoflagellates are especially favorable material: since many members of the group are highly adapted to dwelling in blood, their requirements should reflect the composition of blood in its role of culture medium for blood cells.

*D. Fat-soluble nutrients.* There is as yet no comprehensive scheme for making fat-soluble nutrients adequately accessible to isolated protists and mammalian cell cultures. The problem is manifold — many distinct kinds of nutrients are involved: vitamins A, D, E, and K; unsaturated essential fatty acids and, perhaps most important, fat as fuel and building material. Fat-utilization by protozoa capable of fat-ingestion is under study. Other organisms under study include bacteria requiring oleic acid as a growth factor, and several organisms requiring cholesterol and other sterols. The work on sterols may be useful in developing better means of administering steroid hormones.

Several side-avenues of research have opened up. Perhaps the most noteworthy is the finding that several representatives of the principal phytoplankton groups at the base of the food chains in fresh water as well as salt water require vitamins, especially vitamin B<sub>12</sub> and thiamine. This is directing attention to the role of cyclic fluctuations in vitamin content in water as a significant factor governing the succession of phytoplankton species. These studies have impressed upon us the vast potentialities of the ocean as a source of simple organisms of value in biochemical research.

Another by-product of our investigations has been the

development of better culture media for studying photosynthesis in algae (particularly *Euglena* and chrysoomonads) and purple bacteria. Since an understanding of photosynthesis deepens understanding of fundamental energy distribution mechanisms, so far as possible we have attempted to use photosynthetic organisms for our nutritional studies. Photosynthetic organisms, moreover, offer the feature of self-oxygenation, and thus dense growth is permitted in a small volume without recourse to shaking or forced aeration.

Nutritional studies conducted on fresh-water and marine organisms are directed toward understanding some important ecological factors: the determinants of the growth and decline of algal populations, and the rise of blooms on such waters. Why do diatoms so often predominate in winter, chrysoomonads and chlorophyta in spring and summer, and dinoflagellates in autumn? This succession, observed both in fresh-water and marine environments should reflect common patterns of physico-chemical change and hints at a common nutritional pattern for fresh-water and marine forms belonging to the same groups. One of the distinctions of planktonic organisms revealed in these studies is their prevailing need for media extremely dilute in respect to several major inorganic nutrients.

#### *Collaborative Work*

Many students have collaborated in this work. These include high-school students, college undergraduates, candidates for the Masters degree and predoctoral students receiving training. Several postdoctorate workers have participated.

Collaborative work with other institutions has been maintained and expanded, cultures of test organisms and information have been supplied to an increasing number of workers. Especially close collaboration has been maintained with workers at the Maritime Regional Research Laboratory of the Canadian National Research Council at Halifax;

the National Institute for Research in Dairying, Reading, England; the Hopkins Marine Station of Stanford University; the University of California at Davis and at Berkeley; the University of Rochester Medical School; the University of Pittsburgh; the Department of Microbiology, Yale University; the University of Texas; the U. S. Fish and Wildlife Service, Galveston; the Lederle Laboratories Division of the American Cyanamid Company; the National Dairy Research Laboratories; New York University; the Department of Chemistry, the Mount Sinai Hospital, New York City; the Department of Biology, Brooklyn College; and the Woods Hole Oceanographic Institution.

The work has resulted in a number of papers either published or in press. One member of the staff is serving as co-editor with Dr. André Lwoff of the Pasteur Institute, Paris, for the forthcoming Vol. 2 of *Biochemistry and Physiology of the Protozoa*, and with Dr. William Trager, organized the Conference on Growth of Protozoa, held at the New York Academy of Sciences in the fall of 1952, serving as consulting co-editor of the papers contributed.

### Genetics

THE SCIENCE OF GENETICS has made extraordinarily rapid progress in the past twenty years, so that its "growing points" today have shifted considerably from where they were a quarter of a century ago. At that time the formal application of Mendelian principles to plant and animal systems was expanding widely. The discovery of the giant chromosomes of the salivary tract in the fruit fly *Drosophila* had opened the way for new advances in correlating the staining "bands" of those nuclei with the actual loci of active "genes." The effects of x-rays and other ionizing radiations on the induction of mutations had been described by Muller and his co-workers and even in this period there was great interest in the effects of ionizing radiations on the evolution of populations. Much of the early work of the

laboratory was concerned with studies in radiation genetics, including the rates of induction of mutations at specific loci as a function of x-ray dosage in *Drosophila* and the study of modifications in single-celled spores as a function of ion density when bombarded with electrons and protons directly in high vacua.

The frontiers of genetic research have changed greatly since then. The older lines, to be sure, still persist, especially those concerned with the study of the actions of radiations, but these are now being carried forward so actively and on such a large scale in connection with atomic research that the laboratory has felt that it should discontinue work in this field. Tremendous strides, however, have followed the opening of two new fields. The first, of biochemical genetics, was initiated with studies in *Neurospora* and has been carried forward to a variety of other microorganisms. With its development has come an intensive study of the genetics of microorganisms *per se* including the protozoa and bacteria. It has culminated in the startling finding that even the simplest of bacteria, and at least some of the viruses, appear to have well-defined and essentially conventional genetic systems, and, within the limits of the physical constitution of their chromatin, undergo an inheritance that is essentially Mendelian. The finding that such very simple systems of life, comparatively speaking, are yet capable of following the general mode of inheritance of all higher plant and animal life has brought a new respect for the inherent complexity of even the very simplest living entities, and has done much to encourage the concept that genetic mechanisms may have been one of the earliest characteristics of living things — that the first life on earth may, in a sense, have been "naked genes."

The second revolution in genetics has come more as a realization than as a discovery. Modern genetics was made possible by the quantification of genetic phenomena that Mendel achieved — the demonstration that the predictable ratios with which a "factor" — white eyes in *Droso-*

phila, white coat color in rabbits — would reappear among the first and second generation progeny of known parentage could be represented by simple numbers. It is quite likely that without these striking demonstrations of the “Mendelian ratios” the science of genetics would have been greatly retarded. But by focusing attention on such a simple kind of genetic inheritance, the impression was conveyed that all, or most, genetic modifications behaved in this fashion. Such a notion led to the concept of the gene as a tight, discrete, self-contained entity on the chromosome, largely immune from outer influences within or without the nucleus — a bit like the hard round atoms of Dalton.

It has now become abundantly clear that both of these concepts were over-simplifications. In nature, the kind of mutation which follows the early simple laws of Mendel is a comparative rarity. Most characteristics of plants and animals and men are determined, not by one, but by many “genes” acting both cooperatively and competitively, and, conversely, a single “gene” may affect more than one characteristic of a given organism. A study of the actions and the effects of “polygenes,” as such multi-gene situations are termed, is much more complex than that of simple Mendelian dominants and recessives, but also more practically important. Special statistical techniques are required to deal with it, and these have been evolved in recent years and are still being developed. The other important implication of the “polygene” situation is that genes are by no means independent, but rather are highly interrelated and coordinated in their action. It is now clear that this is true not only at the level of their end effects. Studies of so-called “unstable loci” — gene positions the action of which may become profoundly modified as a consequence of changes in the chromosome in which they occur or even in other chromosomes—indicate beyond question that the whole chromosome of any organism — perhaps indeed the whole nucleus — is a most delicately balanced and interrelated whole, almost as if the chromosome, at least, were a kind of giant molecule.

In this context, the old concept of the gene becomes profoundly changed. It can no longer be thought of as a discrete “bead on a chain,” but at most only as a very short section of a chromosome which, when in normal equilibrium with the rest of the system, behaves in certain ways. Alterations in the system at points far removed spatially from the “gene” can alter its action profoundly and, as it were, “at the source.”

In this changing picture of heredity in the last twenty years, two new and potentially important frontiers have emerged. The first follows from the development of techniques to handle systems of “polygenes” and from the great advances made in the same period in our newer and more complete concept of the nature of Darwinian evolution. It is population genetics — a study of the patterns which genes and their various end products make in the dynamic picture of the evolution of a population of organisms considered as a unit. The second springs from the new importance which the behavioral sciences have acquired in the last several years. It is the study of the genetics of behavioral traits and mental attributes — an extension of the techniques of genetics from the physical to the neural, mental, and behavioral field. The importance of both of these fields in the understanding of man is obvious.

The laboratory is much concerned with this area, and has one program in it — the study of the population genetics of a single organism as related both to certain physical traits and to certain aspects of behavior. The organism selected for the work is one which has not often been used in studies of this kind — the small viviparous Poeciliid fish *Lebistes reticulatus*. It was deliberately selected as a relatively simple vertebrate in which a population similar in many basic characteristics to that of man could be constructed, and which at the same time is a convenient and hardy laboratory animal. The species is characterized by very highly colored males, which are so extremely color polymorphic that no two of them are precisely alike. Some of these color pat-

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terns are inherited in apparently simple Mendelian fashion. Others represent the complex interaction of many polygene systems. Sex determination occurs as in man, the male being the heterogametic sex. The sex chromosomes, however, are much less specialized than in man. A considerable sector of the Y-chromosome contains factors for body structure having nothing directly to do with sex, so that the species offers the opportunity, rare among vertebrates, of studying the distribution in populations of characteristics linked to the Y-chromosome as well as to the X-chromosome and the autosomes. The species forms small social groups which cohere fairly closely in nature, offering interesting theoretical challenges in population analysis. It is one of a complex of closely related forms, none of which, however, exhibit its extraordinary color polymorphism. Some of these are sympatric with it, offering splendid opportunities for the study of speciation. Finally, the male goes through an elaborate and species-characteristic courtship pattern with the colorless female, offering the opportunity for a study of the inheritance of various elements of the behavior pattern in hybrids. To a remarkable degree, the populations of *Lebistes* offer much simplified, but essentially good models of human populations.

Studies in the laboratory on this species currently in progress include basic analyses of a number of the color-inheritance systems (necessary preliminaries to studies of their behavior in the population considered as a unit), studies of the distribution of several systems which have been already worked out within controlled and wild populations, investigations of speciation, and, most recently, studies of the inheritance of elements of the courtship pattern.

The work has been carried forward in collaboration with various workers at Columbia University, the City College of New York, Harvard University, Cambridge University and the University of London.

THE ORIGINAL PURPOSE of Haskins Laboratories was exploratory investigation in certain border-line fields of biochemistry and biophysics which appeared promising but were largely unexplored. Initial studies were directed primarily toward elucidating a more meaningful picture of the action of ionizing radiations on living tissues, especially single cells. These studies emphasized the acute need for a much broader knowledge of cellular physiology, and the research program was broadened to include problems of growth, both neoplastic and microbial. These fields continue to absorb an important part of the efforts of the Laboratories.

More recently the Laboratories have entered a second major field of interest as a consequence of experience in work undertaken during the war for the National Academy of Sciences. This is in the field of psychoacoustics, and involves a new approach to fundamental aspects of speech. The great importance of communication in every aspect of our lives makes this field of first-rank importance and it is one with which the Laboratories expect to be concerned for a long time to come.

When the Laboratories began their work in 1935, this design for "uncommitted" research in borderline fields was not widely recognized nor understood. Those young scientists who carried the enterprise forward in that day and placed their faith in it often had little to support them but their own vision. With the second World War this view was vastly changed, and today the process of flexible group attack on scientific problems by scientists trained in different disciplines is very generally recognized and followed. The effect of this attitude upon the overspecialization which threatened science even as short a time as ten years ago has been striking and salutary — for science is a unity, in approach and in essence, in spite of the infinite variety of its aspects and the tremendous diversity of factual training which different branches of it require.

The initial staff of the Laboratories had worked together before the organization was founded, at Harvard University and the Massachusetts Institute of Technology. The staff now numbers about forty, of whom about twenty spend most of their time in research and the remainder in other activities — largely teaching — at other institutions. In addition, several research associates and guest investigators whose permanent affiliations are with other universities and colleges are working or receiving training with the permanent staff. The central Laboratories are located in New York City, while a part of the work is carried forward at Union College in Schenectady, with which the Laboratories are affiliated.

During the first four years of operation the work of the Laboratories was centered at Union College and in space generously made available by Harvard University and the Massachusetts Institute of Technology. The location in New York City was made in 1939.

During the war, the Laboratories served at the request of the National Academy of Sciences as the central laboratory for the Committee on Sensory Devices. In this connection, it was the focus of a rather extensive research program on the development of aids to the war blinded. The present program of psycho-acoustical research in the Laboratories took its genesis in certain aspects of this experience. An account of this work is given in *Advances in Military Medicine*, vol. 2, pp. 747-754, Boston, Little Brown & Co., 1948, and in *Blindness: Modern Approaches to the Unseen Environment*, Princeton, Princeton University Press, 1950.

Earlier, in the war years, the Laboratories carried forward a program of studies on traumatic shock and motion sickness in connection with the program of the Committee on Medical Research of the Office of Scientific Research and Development. Its work included synthesis by microorganisms of rare compounds for special uses in war medicine, particularly in England. The Director and Associate Director served throughout the war with the Office of Scientific

Research and Development and the National Defense Research Committee.

An incidental and unexpected product of research was the development of a three color process color camera, which was used during the war in America and in England in recording hospital operations, particularly in plastic surgery. The Laboratories are the entire owners of a small commercial stock corporation, the National Photocolor Corporation, formed to develop and exploit this camera and related devices. Here were developed some commercial applications of photographic techniques originated in the laboratory. During the war a development of its work, undertaken at the request of the Armed Services, was the design of an essential component in anti-aircraft fire control. All revenue from this activity, after taxes, returns entirely to the support of basic research work in the laboratories, unrelated to any commercial development.

## Investigators and Staff

CARYL P. HASKINS,‡ *Research Director*. Ph.B., Yale University, 1930; Ph.D., Harvard University, 1935; D.Sc., Tufts College, 1951.  
FRANKLIN S. COOPER, *Associate Research Director*. B.S., University of Illinois, 1934; Ph.D., Massachusetts Institute of Technology, 1936.  
PAUL A. ZAHL, *Associate Research Director*. A.B., Marquette University and North Central College, 1932; A.M., Harvard University, 1934; Ph.D., Harvard University, 1936.  
SEYMOUR H. HUTNER. B.S., City College of New York, 1931; Ph.D., Cornell University, 1937.  
LUIGI PROVASOLI. Doctor in Agriculture, University of Milan, 1931; Ph.D., Rome, 1939.  
ROY M. WHELDEN. B.S., Colby College, 1915; Ph.D., Harvard University, 1929.  
ALVIN M. LIBERMAN† (part time). A.B., University of Missouri, 1938; Ph.D., Yale University, 1942.  
PIERRE DELATTRE\* (part time). M.A. University of Paris, 1931; Ph.D., University of Michigan, 1936.  
EDNA FERRELL HASKINS.‡ B.Sc., King's College, Durham University, England, 1933; Ph.D., 1937; A.M., Radcliffe College, 1935.  
JOHN M. BORST. Physicist and Engineer, School of Engineering, Delft, Holland.  
LOUIS J. GERSTMAN. B.A., University of Buffalo, 1949; M.A., Harvard University, 1952.  
KATHERINE SAFFORD HARRIS. B.A., Radcliffe College, 1947.  
BARBARA J. McDERMOTT. B.A., University of Michigan, 1949.  
AGNES M. McKEON  
ANDREW A. NOWAK. B.A., University of Maine, 1943.  
JOHN J. McLAUGHLIN. B.S., St. Francis College, 1950; M.S., St. John's University, 1952.  
JEAN COWPERTHWAITTE. B.S., Barnard, 1947.  
IRMA J. PINTNER. B.A., Vassar College, 1938; M.S., Cornell University, 1940.  
JACK STORM. B.A., Brooklyn College, 1949; M.A., Brooklyn College, 1952.  
HELENE NATHAN. B.A., Brooklyn College, 1951.  
MERVYN ELGART  
DAVID ZEICHNER  
WILLIAM WINTER  
ALBERTINE ERIKSEN  
MARGARET-ELIZABETH BISSELL  
ROSLYN SOMER  
ANNE HINCHEY GALLAGHER. B.S., University of Massachusetts, 1930.  
RAYMOND C. HUEY (part time). B.E., West Illinois State Teachers College, 1935.

‡ Serve without salary

† Department of Psychology, University of Connecticut, and Haskins Laboratories

\* Department of Linguistics, University of Pennsylvania, and Haskins Laboratories

## RESEARCH ASSOCIATES

SHELDON AARONSON.§ B.S., City College of New York, 1944; M.A., University of Pennsylvania, 1948; Ph.D., New York University, 1953.  
HELEN SIMPSON VISHNIAC.¶ B.A., University of Michigan, 1945; M.A., Radcliffe, 1947; Ph.D., Columbia University, 1952.  
WOLF VISHNIAC.¶ B.A., Brooklyn College, 1944; M.S., Washington University, 1946; Ph.D., Stanford University, 1952.

## STUDENTS

ROBERT JAY DAVIS, SHELDON GOTTLIEB, ARTHUR HOLDEN, MARVIN SANDERS, and BARTLETT SAUNDERS.

## MAINTENANCE

GINO DELMONICO  
ANDREW HAIDUCK

## GUEST INVESTIGATORS

PETER B. DENES. M.Sc., University College, London.  
DENNIS B. FRY. B.A., Ph.D., Head of the Department of Linguistics, University College, London.  
IRA HIRSH. Ph.D., Central Institute for the Deaf, St. Louis.  
ANDRE MALECOT. A.B., M.A., Ph.D., University of Pennsylvania.  
WILKINSON W. MEEKS. A.B., M.S., Ph.D., Northwestern University.  
MICHAEL BACH. B.S.  
HERMAN BAKER. B.S., M.S.

¶ Department of Microbiology, Yale University  
§ City College of New York

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<sup>1</sup> Department of Psychology, University of Connecticut & Haskins Laboratories

<sup>2</sup> Department of Linguistics, University of Pennsylvania & Haskins Laboratories

<sup>3</sup> With Brooklyn College

<sup>4</sup> With the New York Botanical Garden and Columbia University

<sup>5</sup> Sloan-Kettering Institute for Cancer Research

<sup>6</sup> Department of Microbiology, Yale University

<sup>7</sup> Department of Biology, Brooklyn College

<sup>8</sup> Woods Hole Oceanographic Institute

<sup>9</sup> The New York Zoological Society

Grants — August 1, 1953

American Cancer Society, for research on the nutritional availability of lipid growth factors for microorganisms as a guide to tissue culture, one year (July 1, 1953-June 30, 1954)	\$ 4,700.00
American Philosophical Society, a grant from the Penrose Fund for the purchase of a micromanipulator (April 22, 1952 to completion of project)	1,000.00
Carnegie Corporation of New York, for psychological and physical research on auditory patterns, five years (Dec. 1, 1952-Nov. 30, 1957)	100,000.00
Carnegie Corporation of New York, for consultant services, one year (1952-1953)	7,000.00
Federal Security Agency, Public Health Service grant G-3216 for the culture of algae and other microorganisms objectionable in public water supplies, two years (Sept. 1, 1951-Aug. 31, 1953)	20,625.00
Federal Security Agency, Public Health Service grant C-1622 for studies of blood and tissue levels of various nucleotides as related to tumor growth, two years and five months (Dec. 1, 1951-Apr. 30, 1954)	18,230.00
Lederle Laboratories Division, American Cyanamid Company, a grant in aid of research on the nutritional requirements of various microorganisms, five years (Sept. 5, 1948-Sept. 4, 1953)	12,500.00
Loomis Foundation, a grant in aid of research on the fundamental biochemistry of microorganisms, two years (1951-1953)	13,000.00

Rockefeller Foundation, Division of Natural Sciences and Agriculture, for research in protozoological chemistry, two years (Nov. 1, 1952-Oct. 31, 1954)	20,000.00
Wellcome Research Laboratories, a grant in aid of research on the mode of action of anti-malarials, (May 21, 1953)	1,000.00