Preventive Medicine FOR THE DOCTOR IN HIS COMMUNITY

An Epidemiologic Approach

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SECOND EDITION

McGRAW-HILL BOOK COMPANY INC. 1958
The Blakiston Division
New York Toronto London

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Library of Congress Catalog Card Number: 57-9424

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TO B. S. C. AND B. P. H. L.

PREFACE

This book is directed primarily toward the development of a point of view, a philosophy, and a method of approach to health promotion and disease prevention. We have sought to present a way of looking at health and disease which we believe is essential to the conscientious practitioner who wants to give his patients the kind of thoughtful care they are fast learning to expect.

As an epidemiologic approach to preventive medicine, designed primarily for those expecting to enter private practice, the book has the following objectives:

1. To expand the concept of preventive medicine for wider application.
2. To give an understanding of the essentials involved in promoting health and preventing disease.
3. To point out the value of practicing medicine with a preventive point of view and to motivate practitioners to incorporate this concept in their practice.
4. To develop this philosophy and point of view so as to enable the practitioner to see and appreciate the whole picture of community health activity, realize that the role of the private practitioner in health matters, while essential, is only one of many, and find pleasure in relating his work to the total health job.

The original stimulus to produce this book came from many of those familiar with the pedagogic situation who convinced us of the need for a new approach in a textbook of preventive medicine for medical and dental students. The idea of approaching preventive medicine from the standpoint of the natural history of disease appealed to us, and people in many parts of the world have found it useful as presented in the first edition. This viewpoint, in accord with the newer concepts of epidemiology, aims to define the points or levels in the natural history of any disorder of health at which preventive measures may effectively be applied. The newer concepts of epidemiology are concerned with the multiple factors contributing to the natural history of any disorder, so the epidemiologic approach to preventive medicine is a logical one. Furthermore, since disease prevention is a function of medical and dental practitioners in the locales of their practice, we have included a section on organized community health activities, presented from the practitioner's viewpoint.

This second edition has been expanded, brought up to date, and re-

arranged in accord with suggestions from reviewers and from teachers of preventive medicine. The first part of the book is devoted to basic principles: the definition of preventive medicine, the presentation of the concepts of natural history and levels of prevention in an epidemiologic approach to the subject, and a closely related discussion of biostatistics. Next come discussions of practical applications of these principles to various groups of acute, long-term, infectious, and noninfectious diseases, using specific disorders as illustrations. Then the principles are applied to certain broad fields such as maternal and child health, mental health, occupational health, individual health services, and rehabilitation. The third portion of the book is devoted to the subject of the doctor and his community; these chapters outline and define community health problems and the facilities which are available to the doctor as a leading citizen and the person chiefly responsible for the health of his fellow citizens.

The number of illustrations in this edition has been practically doubled by the addition of charts to demonstrate the practical application of the concepts of natural history and levels of prevention. A new chapter on the natural history and prevention of oral disease has been added, and the chapter on multiple screening in the previous edition has been combined with the one on long-term illness.

Textbooks in medicine, surgery, and the various medical specialties provide information that can easily be fitted into the concept of preventive medicine advanced in this book. The best teachers in these fields teach the phases of preventive medicine applicable to their own specialties. The same is true of texts and teachers in microbiology, parasitology, industrial toxicology, legal medicine, and other subjects in the medical curriculum. For this reason, we have not attempted to deal with an inclusive list of diseases, and the book is not intended to be encyclopedic. It should not be used as a compendium or vade mecum. In fact, continuing research is providing medicine with means for earlier application of preventive technics so rapidly that any textbook would be out of date before it could be published, if it attempted to present the latest knowledge in the whole field of preventive medicine.

The modern concepts of epidemiology underlie this whole approach to disease prevention, and since biostatistics is an essential tool of epidemiology, a chapter is devoted to it. But this book is not offered as a textbook of epidemiology or of biostatistics; other books treating of these subjects are available, and each teacher will undoubtedly make his own adaptations to the special needs of his students.

An effort has been made to present a comprehensive picture of community health activities and of the practitioner's relationship to them; but it should be pointed out that this book is not a textbook of public health administration.

Public health is now recognized as a specialty in the United States, with specialty boards for physicians and for dentists working in the field. It is a specialty which requires postgraduate training, and such training is not within the province of a medical school.

No attempt is made to outline community and "field" observation, which should, in one form or another, be part of any comprehensive course in preventive medicine for medical students. Despite differences of opinion as to the ultimate value of certain "field trips," it is agreed that if this type of work is to be successful, it must be very carefully planned with the needs of both the students and the health agency in mind.

It is apparent that a number of contributors are required to present these concepts as they pertain to various specialized fields. We are most fortunate in having had the assistance of men who not only have the required special knowledge but are also experienced in teaching preventive medicine. We are deeply grateful for the fine spirit in which they have cooperated in developing their subjects according to the over-all plan of the book.

An excellent companion volume to this book is the collection of papers edited by John Hubbard under a title which coincides with the third level of prevention in our book: "The Early Detection and Prevention of Disease" (McGraw-Hill–Blakiston, 1957). Appropriate references are made in the various chapters of our book to corresponding sections of this companion volume.

Permission to use various quotations, tables, charts, etc., from a number of publishers and authors is gratefully acknowledged and is noted at appropriate points. The authors and editors fully realize that many others than those enumerated herein have made certain contributions to this concept of preventive medicine. Indeed, it is possible that the actual phraseology of others may have been used unintentionally. In this, as in other professional fields, such inadvertent use of well-turned phrases of others is inevitable in spite of precautions against it. There can be little doubt that the thinking of others has, in some degree, molded the ideas of the authors. To these persons, though unnamed, go our grateful acknowledgments. Particular reference must be made to the works of Drs. Wade Hampton Frost, John E. Gordon, and W. H. Perkins, on which the epidemiologic viewpoint of the text leans very heavily. For assistance with the manuscript we are grateful to Elizabeth Brown, Martha Breed, and Rose Komeier.

The principles are dedicated to the promotion of health and the prevention of disease. The volume itself is, as before, dedicated to our wives, who continue their tolerance and support.

E. GURNEY CLARK
HUGH R. LEAVELL

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INTRODUCTION

This book is based on the following principles:

1. Any disease or morbid condition in man is the result of a dynamic process. From its earliest beginning, the dynamic process follows a more or less characteristic series of events in the environment and in man until the affected individual returns to normal, reaches a state of equilibrium with the disease, defect, or disability, or dies. Disease, therefore, is not a static condition but a process which follows a more or less natural history.

2. This process evolves as a result of multiple causes affecting the interaction of individual hosts and disease agents. Furthermore, characteristic effects are produced upon the mass of the population as well.

3. Effective preventive medicine requires that this process be interrupted as early in its course as possible. It is the province of epidemiology to study these multiple causes and effects and to investigate the qualities of an interaction among the individual and aggregate hosts, the agents which produce disease or injury, and the environment in which the reactions take place.

4. "Normality" and "health" are relative attributes and require careful statistically controlled studies for definition. Health involves mental and social as well as physical factors.

From these principles certain corollaries are drawn:

1. The evolutionary process of disease is, in many cases, susceptible to interruption in order to limit its further progress or the speed of its progression.

2. As disease involves interaction phenomena among host, agent, and environment, prevention may be achieved by so altering one or more of these three elements that interaction does not take place or is interrupted in favor of man.

3. Since it is essential to recognize disease in the individual at the earliest possible time, so that all available preventive measures may be applied to prevent or retard its progress, it is highly important for the practitioner to be able to detect slight deviations from the normal. To do this, he must have as clear a picture as possible of the normal and of the biologic range within which an individual observation may be considered to fall within normal experience. The very earliest and perhaps the slightest changes brought about by disease processes cannot be detected in many instances

by presently known means, although medical research is bringing these changes progressively nearer the horizons of detection.

4. Since most available preventive measures operate with greatest effectiveness when applied either to individuals who are still unaffected or to those in whom the disease process is in its early stages, these measures are most effective when applied on a general positive basis to the unaffected or to those already affected but symptom-free. Therefore the practitioner of preventive medicine must so plan his work that he may examine and advise such individuals before the morbid process is apparent to them. This preventive practice involves periodic health examinations at such intervals in the life of the individual that times of special stress or of disease susceptibility and exposure are taken into account and selective examinations made more frequently at these times.

5. The doctor's accomplishments in preventive medicine are limited by the incomplete knowledge of specific preventive measures, expense of application, time factors, and patients' reactions. Thus complete success will not invariably follow. The practitioner must therefore work for the good of the greatest number. He should apply those measures proved to be of greatest value in the sex, age, and stress period in which the person to be examined falls and employ those tests which may be applied with the greatest efficiency and economy to considerable numbers of individuals.

6. As preventive medicine is most effectively practiced before symptoms are observed by the patient himself, the private practitioner's contribution is materially diminished if he delays until the patient comes to him with complaints. The practitioner should, therefore, give prompt and thorough attention to those in apparent health who apply for advice, and he should make available comprehensive care, including preventive services for the entire family as the basic social unit. Such a concept of prevention is beneficial to the individual and the community. Arrangements for periodic consultations at suitable intervals to discover the first evidence of deviation from the normal can be made without impropriety.

7. The practitioner of preventive medicine must consciously practice health education. This involves not only informing the patient but also utilizing means of so motivating him that the practitioner's advice is actually followed. It is especially important to establish in the healthy individual a strong desire to remain well, since he is less strongly motivated to follow advice concerning health than the person who suspects he is ill.

8. Since health is considerably more than absence of disease, it is logical that appropriate measures be taken to investigate the habits and customs of the individual which have a bearing on his health and to guide them toward health promotion and disease prevention.

9. There is little if any real difference between the practice of preventive medicine at any level of prevention and the practice of the best medicine possible at any given stage in medical development. The practitioner of good medicine can, therefore, scarcely avoid the practice of preventive medicine, once he adopts the philosophy and point of view that medical treatment is in itself preventive and that more is accomplished by earlier application of his skills.

10. The over-all field of health, which is of concern to every citizen, is a complex one involving many people of diversified professional backgrounds, many expensive physical facilities paid for by all sorts of people, and economic problems of all kinds. Administrative skills are required to coordinate the related activities so that they are carried out as an effective whole. Intelligent participation of the people involved is essential to successful accomplishments in health.

The practitioner of preventive medicine on an individual or mass basis, therefore, needs to understand the complexities of the entire field of health activity as well as the aims and objectives of and the parts played by all the groups concerned. Without this understanding, he is merely a therapeutic artisan performing a limited task as part of a health production line, with little comprehension of the significance of his own contribution. With it, he is a truly professional worker with the joy of doing his part in a broad task of great significance.

Part 1

BASIC PRINCIPLES

Chapter 1

WHAT IS PREVENTIVE MEDICINE?

This subject is broader than merely the prevention of the occurrence of disease. Medicine must also be concerned with promoting health and with the prevention of total disability by rehabilitation of those damaged by the disease process. The term *preventive medicine* is widely used and generally accepted, and it will be employed here in a sense sufficiently broad to include health promotion, treatment, and rehabilitation as well as specific protection.

Much confusion has arisen between the terms preventive medicine and *public health*. Attempts to differentiate these terms by definitions alone are likely to confuse further rather than to enlighten. It is better to consider first, on the one hand, how a public health director practices preventive medicine and how, on the other, the private practitioner applies it. Both are practicing preventive medicine in the sense that the term is used in this book, but their points of view and emphases differ in many respects.

THE PRACTICE OF THE PUBLIC HEALTH DIRECTOR AND THAT OF THE PRIVATE PRACTITIONER

Essential Differences

Not so many years ago the dividing line between public health and private practice was clearly defined. Sanitation of the environment and certain community measures requiring legal authority designed to prevent the spread of communicable diseases, such as isolation and quarantine, were admittedly in the public health sphere. Practically everything else in the health field was in the province of private practice.

Now the line of demarcation is much less sharp, and there are fringe and borderline health problems, the responsibility for which has been at times rather hotly contested. The following list gives the essential differences between the practice of the public health director and that of the private practitioner:

Public Health Director	*Private Practitioner*
1. He is trained as a specialist in preventive medicine.	1. He is a "general practitioner" of preventive medicine. This is true whether he is a specialist in some branch of dentistry, medicine, or surgery or a general practitioner in all respects.
2. His primary concern is with the various aspects of prevention.	2. His primary concern has been conventionally with the treatment of disease and injury.
3. His patient is the community, and his major concern is with disease as it affects groups of people. In numerous instances, of which the health of mothers and children is a good example, the approach to the group must be through individual patients.	3. His patient is an individual, though he may take responsibility for the health problems of an entire family.
4. He seeks health procedures which can be applied economically to large numbers of people with satisfactory results for a high percentage of them.	4. He strives to approach perfection in serving the individual patient, despite expense which would preclude application of such procedures generally in the community.
5. He uses community health education technics to persuade individuals to avail themselves of helpful procedures.	5. He is bound by medical ethics not to "advertise" for patients, although individual and family health education is his duty.
6. He functions through organized community effort and has legal backing if it should be necessary in certain cases.	6. He functions as an individual provider of health services, with legal obligations but no legal authority except the right to practice.
7. He and his associates are financed by funds coming largely from taxation.	7. He is usually paid by individual fees, which may or may not be covered by some form of insurance.
8. He is responsible to the entire community in which he practices his specialty.	8. He is responsible directly to his patient, who is nevertheless protected legally against malpractice.
9. He has a sort of "monopoly" in certain aspects of mass preventive medicine in the geographic area in which he works.	9. He is in competition with other practitioners in his geographic area.
10. He must deal with many administrative problems, since his department ordinarily employs a number of people and is a branch of government, and its successful operation requires the cooperation of many agencies and individuals.	10. His administrative problems are minimal, since his practice has the characteristics of a small business.

Reasons for Merging of Interests

1. Increased knowledge has made possible specific prevention of some diseases and retardation of the progress of others by dealing with single individuals, rather than by broad community action (such as water purification or the pasteurization of milk). The type of prevention which involves treatment (venereal disease, tuberculosis) is carried on by health departments under certain circumstances, getting the health department into the treatment field, which the private practitioner had considered to be his alone.

2. Costly diagnostic and treatment methods overtax the resources of a larger proportion of the community than did the services of the old-fashioned doctor, who required only the contents of a small black bag.

3. A social revolution has occurred in many parts of the world, with new value placed on the health of the individual, whether as a right under a democratic state or as a means of increasing productivity in a dictatorship. Individual health has become an important concern of the community.

4. Efficient methods of paying practitioners for health-promotional and specific protective services have not been widely developed. Some groups of practitioners, such as pediatricians, obstetricians, and dentists, have emphasized broad preventive services in their practice, and the public has been educated to pay for them.

5. The rapid growth of specialization in medicine has to a considerable extent broken down the intimate relationships and the feeling of responsibility that the family doctor of former days had for the health of the families under his care. Individuals now are likely to shop around from specialist to specialist, depending on the symptoms they have.

6. Because it is often less dramatic than medicine directed primarily at therapeusis, preventive medicine has not had the appeal for practitioners which is warranted, nor has it been given its deserved recognition in medical education.

Results of Merging Interests

1. Where organized community effort was needed to accomplish a health objective that the public needed and wanted, voluntary health agencies have been organized to do the job, or departments of public health as agents of the people have been given the legal responsibility for accomplishing the desired result.

2. There has been a tendency to divide the preventive job between the health department and the practitioner on an economic basis. Health departments have tended to serve those in the lower income brackets, leaving the remainder of the population to practitioners. Public health has emphasized health-promotional, specific-protection, and case-finding procedures, referring patients found in need of treatment to private physicians.

3. Prepayment insurance plans which have developed to spread the heavy costs of medical care usually make no provision for specific protection and other services which are primarily preventive in nature. This has tended to steer patients who need such services to the health department, where they may usually be obtained free.

4. Increased general taxes have resulted in demands from a number of people for more services from their tax-supported agencies. Others, appalled by higher

taxes, have wished to curtail government services beyond the point of community safety.

DEFINITIONS

Winslow,[1] former Professor of Public Health at Yale, in 1920 defined *public health* as follows:

> Public health is the science and the art of preventing disease, prolonging life, and promoting physical and mental health and efficiency through organized community efforts for the sanitation of the environment, the control of community infections, the education of the individual in principles of personal hygiene, the organization of medical and nursing service for the early diagnosis and preventive treatment of disease, and the development of the social machinery which will ensure to every individual in the community a standard of living adequate for the maintenance of health.

Using the first part of this definition, ***preventive medicine*** might be defined as follows: preventive medicine "is the science and art of preventing disease, prolonging life, and promoting physical and mental health and efficiency."

This definition applies to preventive medicine as practiced by either the medical or dental practitioner dealing with his individual patients or the public health practitioner dealing with groups of individuals in his community.

As illustrated in Fig. 1, both private and public health may then be considered as divisions of preventive medicine, public health being the part which requires organized community effort or action. This latter is the major field of the health director, but the private practitioner also plays his role in this field as a member of a large team of health workers and agencies, and not merely as the doctor "in charge of a case."

The agencies set up to carry on organized community health activities may be:

1. Voluntary (nonofficial, private, supported wholly or in large part from nontax funds).
   Examples: voluntary hospitals, tuberculosis associations, private foundations, etc.
2. Governmental (official, public, tax-supported).
   Examples: governmental hospitals, health departments, etc.

For the purposes of these discussions, health work carried on through organized community effort is public health work, whether done by a voluntary or a governmental agency. In this sense the word *public* refers to the people of the community, who decide that concerted action is needed to accomplish its health goals.

The work done by governmental health departments is referred to on occasion in this book as *conventional public health*, because *public health* has been used by some in a restricted sense as applying *only* to health department work.

Social medicine[2, 3] is the term being used widely in Western Europe to emphasize the importance of man's environment to his health. In this

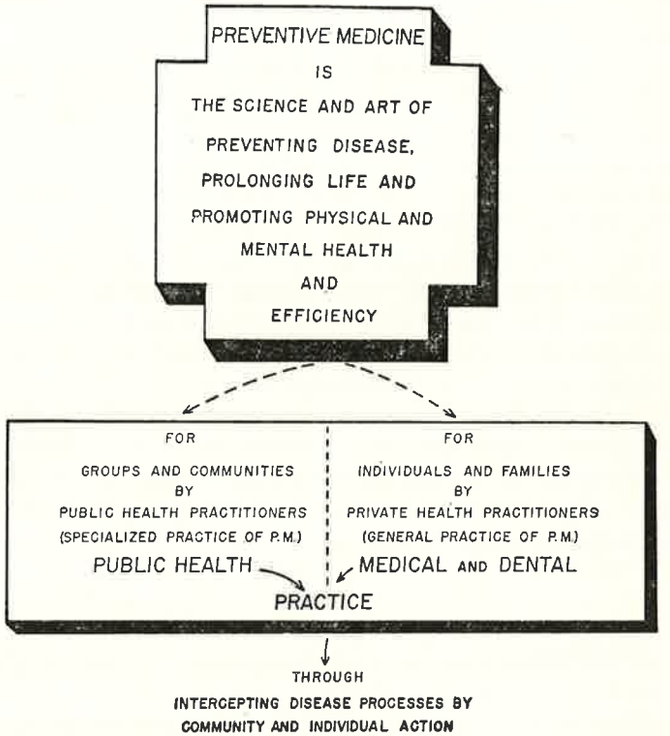

FIG. 1. Preventive medicine. Its definition and practice.

sense, *environment* includes the human society in which man lives and the multitude of complex interpersonal relationships that so profoundly affect his health (Chap. 3). Those who accept a broad view of preventive medicine find little difference between their concept of the meaning of this term and that of social medicine as understood in Western Europe, Canada, and a number of other countries.

Medical care is another term which needs definition. It may be interpreted in various ways:[4]

1. Services of physicians as distinguished from surgeons.
2. Care of sick people in contrast to preventive services for healthy persons. In this sense, one would include "the services of physicians, dentists, nurses, and

hospitals and the provision of drugs, orthopedic appliances, eyeglasses and so forth."

3. An even broader use of the term is:

> . . . the systematic organization of *all the personal services* by members of the various health professions and all the clinic, hospital and related facilities necessary to attain the highest level of health, prevent disease, cure or mitigate illness, and reduce if not prevent disability, economic insecurity and dependency associated with illness. . . . It expresses the concept of *a unified service for the individual in health and sickness* in place of separate approaches, one confined to prevention of illness, and the other to treatment of the sick. It points to the bearing of comprehensive medical care on the economic conditions of the individual, the family, the community and the nation. . . . This broad interpretation distinguishes personal services to the individual from mass prevention through such measures as sanitation of man's environment and from group contact as used for mass information on healthful living and health resources.[4]

The latter interpretation might very well be described as *comprehensive medical care*. In general, this broad definition of medical care has the same meaning as the five levels of prevention discussed in Chap. 2. It has been well said that the best medical care which modern knowledge makes possible is bound to include all preventive measures of value to the individual in a given situation. However, the concept of prevention of this book also includes measures such as pasteurization of milk, purification of water, etc., which are applied on a community basis rather than on an individual basis. It is therefore somewhat more inclusive than the foregoing definition of medical care.

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Chapter 2

LEVELS OF APPLICATION OF PREVENTIVE MEDICINE

THE OBJECTIVES OF PREVENTIVE MEDICINE

The ultimate objectives of all medical, dental, and public health practice, whether carried out in the office, the clinic, the laboratory, or the community at large, are the promotion of health, the prevention of disease, and the prolongation of life. These objectives coincide with the definition of preventive medicine in Chap. 1, "the science and art of preventing disease, prolonging life, and promoting physical and mental health and efficiency." The objectives of preventive medicine are to promote positive or optimum health, to prevent departure from health, and to prevent disabling illness after the onset of disease in man.

Disease is defined in "Webster's New Collegiate Dictionary" as "a condition in which body health is impaired," and *health*, as "the state of being hale, or sound in body, mind or soul, especially freedom from physical *disease* or pain." According to the constitution of the World Health Organization, "health is a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity." A more dynamic concept of health is presented by Perkins: [1] "Health is a state of relative equilibrium of body form and function which results from its successful dynamic adjustment to forces tending to disturb it. It is not passive interplay between body substance and forces impinging upon it but an active response of body forces working toward readjustment."

DISEASE AS A PROCESS

Everyone has health of some kind: those in excellent condition with no complaints, those who are fairly well, those feeling under par, and those who are definitely ill. Thus, health may be thought of on a graded scale, just as is disease or disability. It may be affected by living and nonliving disease agents, by the inherent and acquired characteristics of man, and by the many factors of the environment in which man lives. Neither

health nor disease is static or stationary. Behind every condition of health or disease is the phenomenon of almost constant alteration. These conditions are continuing processes: a battle on the part of man to maintain a positive balance against biologic, physical, mental, and social forces tending to disturb his health equilibrium. The potentialities for the success of man's struggle for health maintenance are manifested in his internal and external defense mechanisms against disease-producing stimuli, the great margins of safety and tissue reserves, and in the physiologic processes of repair of which he is capable. In regard to *communicable* disease, health depends on the outcome of a biologic phenomenon, the competition of living things, man and his parasites, for food, shelter, and suitable conditions for propagation. In regard to *noncommunicable* disease, man's health is a reflection of his success in combating nonliving agents of disease. These latter agents may arise in man himself as a result of heredity or of changes in physiologic function, or, just as infectious agents do, they may come from the environment outside of man as a result of his inability or failure to cope with disturbing external disease stimuli. Whatever the source or the type of the disease stimulus, and whatever the extent of man's response, the result is a *process*. Disease is not a static entity but a process which actually begins *before* man himself is affected.

THE NATURAL HISTORY OF DISEASE AND MULTIPLE CAUSATION

The disease process in man depends on the characteristics of disease agents (living or nonliving), the characteristics of man, and man's response to disease-producing stimuli [2] arising in the environment or within man. This epidemiologic concept is considered in detail in Chap. 3.

Every condition of health and disease in man has its origin in other processes before man himself is involved. For example, man is the reservoir of the plasmodium, but new malarial infections depend upon agent and environmental conditions outside of man: the presence of the anopheles mosquito, environmental conditions satisfactory for its propagation, and habits and customs of man in regard to protective devices. Another example is lead poisoning, which depends on the conditions in the environment that bring the disease agent (lead) to man, e.g., the use of discarded storage batteries as fuel for open fires and the resulting inhalation of the fumes. The intermarriage of genetic carriers of hereditary disease and of certain genotypes leads to hereditary disorders in the offspring. Thus, precipitating and predisposing forces or causes may be continuously operative in the occupational or living environment of man. Heredity, social and economic factors, or physical environment may be creating a disease

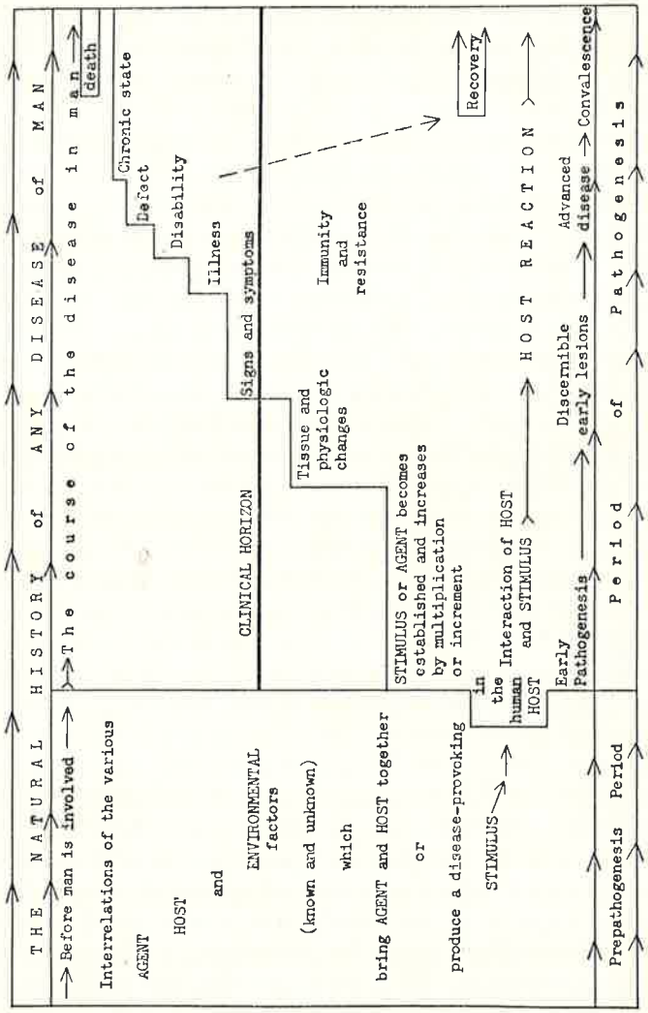


FIG. 2. Diagram of the important elements in the natural history of any disease process in man.

stimulus long before man and stimulus begin to interact to produce disease. This preliminary interaction of potential agent, host, and environmental factors in disease production may be termed the period of *prepathogenesis* (Fig. 2).

The course of a disorder in man from the first interaction with disease-provoking stimuli to the changes in form and function which result, or until equilibrium is reached or recovery, defect, disability, or death ensues may be termed the natural *course* of the disorder, or period of *pathogenesis* (Fig. 2). Man interacts with a stimulus (an environmental situation, an infectious agent, physical force, a chemical substance, etc.) and responds with tissue changes or with an altered type of reaction in which tissue changes are not demonstrable with present methods (certain mental disorders, etc.); tissue change or altered reaction is often followed by signs and symptoms and a more or less typical course until terminated by time or treatment. For example, from a mosquito infected in an uncontrolled environment, plasmodia (sporozoites) are injected into man; in 3 to 14 days, gametocytes appear in the blood, followed, after further incubation, by signs and symptoms characteristic of malaria. These signs and symptoms recur periodically unless interrupted by some form of treatment. Similarly, vaporized lead from environmental sources enters the respiratory tract, gains access to the blood, is deposited in the bones, and, after sufficient increments, may produce a stimulus which calls forth a response: tissue changes, and signs and symptoms of lead poisoning. A dominant gene from one parent may combine with a similar one or a recessive gene from another parent and create a stimulus which will produce a disease process characteristic of that combination, e.g., Huntington's chorea.

These and other conditions can be clinically diagnosed (i.e., reach the *clinical horizon* of Fig. 2) after recognized periods of incubation, or periods of added increments of noninfectious agents, or periods of tissue response to other types of disease stimuli. The process above the clinical horizon is better known than what takes place earlier. Inadequate information about the preclinical process is an outstanding gap in knowledge in medicine.

The combination of the processes of these two periods (i.e., the process in the environment—*prepathogenesis*—and the process in man—*pathogenesis*) may be termed, for preventive purposes, the *natural history* of a disease. It comprises all the interrelations of the agent, host, and environment affecting the complete process and its development from the first forces which create the disease stimulus in the environment or elsewhere, through the resulting response of man, to the changes which take place leading to defect, disability, recovery, or death.

Figure 3 illustrates some of the elements in the natural history of essential hypertension. Very little is known with any degree of certainty

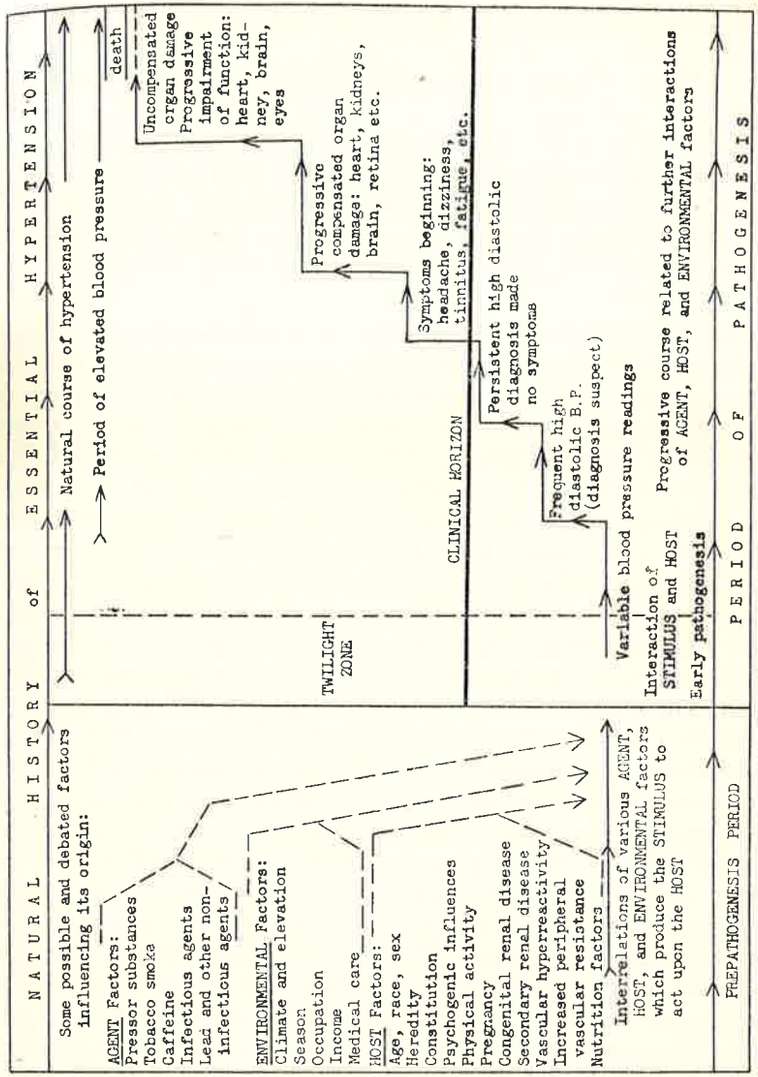


FIG. 3. Diagrammatic representation of some of the elements in the natural history of essential hypertension.

about the causes which lead to its onset in man; prevention awaits this knowledge.[3]

The condition of health is the result of constantly reacting forces, and the occurrence of disease in individuals or its distribution in groups can be understood best by a consideration of the multiple *causes* influencing the agent-host relationships in the environment both before and during the period of pathogenesis. A cause is that which brings about a result or an effect. The complex process of deviation from health is the result of continuous chains of causes and effects, not of single or specific causes alone.

The concept of *singleness* of cause gained momentum with the coming of the bacteriologic era, to the extent that causes relating to the host and environment were often forgotten in the enthusiasm over the isolation of specific living agents. Many believed that when the agent and its means of transmission were identified, the problem of prevention was solved. It is unreasonable and unrealistic to subscribe to such a concept. The tuberculosis organism is only *one* cause of the disease tuberculosis. Only a fraction of those whose tissues have been invaded by this organism have clinical tuberculosis. The additional causes lie in the environment, in the habits, customs, inherent constitution, and nutrition of those infected with the *Mycobacterium tuberculosis*. An excess of fluorides in drinking water causes mottled enamel only when taken during the early period of dentition. The living causative agent of syphilis is the *Treponema pallidum*; yet not everyone gets syphilis who is directly exposed to it, nor do all those who get the disease exhibit the same course; men and women react differently, and there are also racial differences in reaction. Causation in communicable disease cannot be explained on a purely bacteriologic basis, since such an explanation ignores completely the fact that there are two living organisms involved—man *and* microorganism—and that these two interact and are acted upon by external forces. The important nonbacteriologic causes of cholera and its prevention and control were described by Snow [4] long before the cholera vibrio was discovered. Even with the discovery of specific living agents, it does not follow that all the causal factors in the genesis and behavior of a disease are revealed, as is amply illustrated by typhoid, many causes of which are environmental.

When some or all of the multiple causes of a disease process are determined, prevention depends on taking appropriate measures to counteract or intercept these causes. Perkins has put the whole philosophy of prevention into a single phrase: "To oppose or intercept a cause is to prevent or dissipate its effect." [1] This is the objective of preventive medicine. Such action has long been a principle in preventive medicine applied to *groups* of individuals. Its application on an individual or family basis lies within the province of the private practitioner. He needs only to follow the

advice of Paul,[5] who urges him to go beyond the patient himself and be concerned with the *circumstances* under which human disease is likely to develop. Answers must be sought to "why" as well as to "how." The doctor, or *clinical epidemiologist*, as Paul terms him, should

> . . . start with the sick individual and cautiously branch out into the setting where that individual became sick—the home, the family and the workshop. He is anxious to search for other members of the family or community group who are actually or potentially ill. It is his aim to thus place his patient in the pattern to which he belongs rather than to regard him as a lone sick man who has suddenly popped out of a healthy setting, and it is also his aim to bring his judgement to bear upon the *situation* as well as on the patient.

There is really nothing new in this concept—it is the "heart and soul of the family practice of medicine"; but with the practice of medicine shifting away from the home and into the hospital and dispensary, there is danger that this concept may be lost. Paul insists that there is much to be gained by this approach and that the trail must be blazed by the clinician, since he is the one who must shoulder responsibility for the work.

With the concepts of multiple causation, of the natural history of disease as defined here, and of the progressive departure from health toward disease, defect, disability, and death, it is possible to construct a schema for the application of preventive measures. Since causal elements of disease may arise from living and nonliving disease agents, from man's environment, or from within man himself, these factors in disease occurrence must be examined in detail if causes are to be intercepted and their effects prevented.

In Chap. 3 the relationship of epidemiology to preventive medicine is presented both in terms of describing what is known about the natural history of disease and also in terms of a method to fill the gaps in knowledge about agent, host, and environmental factors in the natural history. In that chapter * it is shown that disease *agents*, defined as substances or elements the presence or absence of which may initiate or perpetuate a disease process, may be nutritional, physical, chemical, or biologic. Their contribution to disease production depends on their biologic, chemical, or physical characteristics, the reactions they stimulate in man, their reservoirs and sources in nature, and the vehicles and conditions of dissemination to man. *Environment* is defined as the aggregate of all the external conditions and influences affecting the life and development of an organism. Thus the environmental factors in disease causation may be related not only to the physical aspects of the environment but also to the social, economic, and biologic factors which impinge upon man's physical and mental health. Such a broad view of environment suggests that it comprises all things except man himself. This, indeed, may be the case, but

* See pages 50–62 for details.

since specific disease agents themselves and their inherent characteristics are so important and play such a prominent role in disease causation, they are considered herein as a category apart from environment, although they are inseparable from it. Among the human *host* factors in disease occurrence and distribution are age and sex, habits and customs, general and specific defense mechanisms, heredoconstitutional make-up, and psychobiologic characteristics and reactions.

Prevention, therefore, at any given level of application in the progressive natural history of any disorder, depends on the knowledge of multiple causes related to these agent, host, and environmental factors and the ease with which the causes may be intercepted or counteracted. Prevention requires the construction and interposition of various kinds of barriers to the interaction of these elements. The degree of success in prevention depends on the completeness of knowledge regarding the natural history of a disease, the opportunities to apply this knowledge, and the *actual* application of it. It is not necessary to know *everything* about the natural history of a disease in order to initiate preventive measures, yet in many instances complete success cannot be achieved because current information is too meager. Nevertheless, the interception of any of the causes at any stage of prepathogenesis or later may have its effect on the morbid process by preventing its further development along lines detrimental to man's health. This epidemiologic concept permits the inclusion of treatment in the schema of prevention, since treatment interrupts the process. Thus it is preventive, in that sense. This concept also opens to the practitioner of preventive medicine a broader spectrum of potential activity, in which preventive measures can be applied earlier and with greater latitude.

LEVELS OF PREVENTION

Prevention, as used in this textbook, has the meaning it had in Elizabethan times, "to come before or precede,"[6, 7] and conforms with the present dictionary definition of *prevent*, "to anticipate, to precede, to make impossible by advance provision." Such prevention requires anticipatory action based upon the knowledge of natural history, in order to make the onset or further progress of disease unlikely. Anyone practices preventive medicine who utilizes modern knowledge to the best of his ability to promote health, to prevent disease and disability, and to prolong life. This means merely good medical and dental practice for individuals and families and good public health practice[20] for communities (see Fig. 1, Chap. 1).

Prevention may be accomplished in the PREPATHOGENESIS period by measures designed to promote general optimum health or by specific protection of man against disease agents or the establishment of barriers

against agents in the environment. These procedures have been termed *primary* prevention.[8]

As soon as the disease process is detectable, early in PATHOGENESIS, so-called *secondary* prevention may be accomplished by prompt and adequate treatment.

As the process of PATHOGENESIS progresses, it is still possible to accomplish prevention by what might be termed *corrective therapy*, or *tertiary* prevention. When disease has advanced beyond its early stages, treatment may prevent sequelae and limit disability, and even later when defect and disability are fixed, rehabilitation may play a preventive role (Chap. 16).

Within these three phases of prevention (primary, secondary, and tertiary) there are at least five distinct levels at which preventive practices may be applied, depending upon the completeness of knowledge of natural history.[9, 10, 11] These five levels of prevention are (*a*) health promotion; (*b*) specific protection; (*c*) early diagnosis and prompt treatment; (*d*) disability limitation; and (*e*) rehabilitation. They are not static or isolated phases of prevention but form a continuum corresponding to the natural history of any disorder. Figure 4 shows these five levels of application of preventive measures in relation to the natural history of disease as illustrated in Fig. 2. It gives the general preventive measures, well known to everyone, classified as to the most effective point of application in the natural history.

Primary Prevention (Health Promotion and Specific Protection)

HEALTH PROMOTION The procedures employed in *promoting* health are not directed at any particular disease or disorder but serve to further general health and well-being. Health education and motivation are vitally important in this connection. The chapters that follow emphasize the importance of general health promotion in the prevention of specific disorders. Procedures which promote health include a good standard of nutrition adjusted to the various developmental phases of life, taking into account the period of rapid growth and development in infancy and early childhood, the physiologic changes associated with adolescence, the extra demands during pregnancy, and the variations in nutritional requirements of the aged as compared with those of the young adult. These phases of health promotion are discussed in detail in Chaps. 6 and 12.

Health-promotional activities through the realization of the needs for optimal personality development are discussed in Chap. 13. In this chapter it is emphasized that much can be done on an individual or group basis through counseling and properly directed parent education to provide the

FIG. 4. Levels of application of preventive measures in the natural history of disease.

environmental requirements for the child's proper personality development.[21] It will be seen that attention to the family and to the individual is not in itself sufficient for fostering a state of complete physical, mental, and social well-being. The extent of participation in community life may also be an extremely important factor in promoting individual and group health.

Other items in the health-promotion category are adequate housing, recreation, and agreeable conditions in the home and in the occupation. Sex education and counseling before and during marriage may have a specific effect on the exposure to venereal disease, but in general they promote health by favorably influencing marital adjustment.

Genetics, as shown in Chap. 11, has its health-promotional component in its outstanding contribution to increased production and yield among many breeds and varieties of animals and plants. This has resulted in the development of a better and more abundant food supply. Also, in addition to the contribution of genetics to specific protection (Chap. 11), the considerable advances in the study of the management of mutations may have tremendous implications for health promotion in the future.

Periodic selective health examinations, although primarily devised for the earliest detection of morbid processes, may also promote health in their basic appeal to persons to come for examinations *before* they are ill. The opportunities for health guidance under such circumstances are great. These possibilities are discussed in Chap. 15. Furthermore, the educational aspects of cancer prevention, discussed in Chap. 8, need not be limited to pointing out the early signs of malignancy but can play their part in the general health-promotional propaganda that is needed by the population at large.

Finally, since everyone has health in some degree, every illness that brings the patient to the doctor offers an opportunity for advice not only concerning treatment of that illness and prevention of further disability from it, but also as to how the remaining health potential of the patient may be maintained. Such advice extended to the remainder of the patient's family may have considerable effect in promoting health for a larger circle of individuals.

SPECIFIC PROTECTION This is prevention in its conventional sense and comprises measures applicable to a particular disease or group of diseases in order to intercept the causes of disease *before* they involve man. Great progress has been made at this level of application of preventive measures through detailed studies in the laboratory, in the clinic, and in the population. These investigations have produced knowledge of the details of the natural history of many disorders. Lessons learned over the years in the study of epidemics and of communicable diseases which have

led to specific preventive measures can now be applied in the investigations of other conditions that affect groups of individuals. Much already has been accomplished in specific protection against noncommunicable diseases, and the prospects for future development are great.

Before the era of bacteriology, preventive measures were formulated on a more or less empirical basis as a result of detailed epidemiologic studies. The discovery of infectious agents of disease soon led to widespread prevention with greater confidence. With the agent known, specific studies were made in the laboratory, the clinic, and the field on the life cycles of the microorganisms, and means were devised to interrupt these cycles and protect man against infection. Similarly, the discovery of noninfectious disease agents, the reactions they produce in the human host, and their sources in the environment permits action to be taken to intercept them before pathogenesis is initiated. Specific protection against toxic hazards in industry (Chap. 14) illustrates the application of this level as an important part of occupational health programs.

Advances in the knowledge of nutrition have indicated the specific protective measures necessary for the prevention of many nutritional disorders. The agent in most nutritional disorders, except in obesity, is a qualitative or quantitative deficiency of essential nutrients. There are, however, other multiple causes that relate to the host or his environment. Dietary habits may result in malnutrition, or improper assimilation of ingested food may contribute to this disorder. The environment is of particular importance, not only in its physical aspects relating to the production of food elements, but also in its social and economic components as they affect the ability to purchase the foods needed to maintain good nutrition.

Although there is a paucity of knowledge concerning the prepathogenic phases of the complex natural history of cancer, there are aspects of cancer prevention which fall in the level of specific protection: those having to do with the avoidance of various carcinogenic agents and with the treatment of precancerous lesions.

Specific protective measures are applicable to many other disorders, such as allergy, conditions involving the special senses, accidents, dental fluorosis, dental caries, and goiter. The preventive aspects of some of these conditions are discussed in Chaps. 6, 9, and 10.

The geneticist has contributed materially to specific protective measures by illustrating the importance of the detection of genetic carriers of hereditary disease. As shown in Chap. 11, the potentialities of this field of preventive medicine need further exploration to provide the practitioner with new tools.

The primary focus of any program of preventive medicine applied to the individual, as illustrated in Chap. 15, is on specific protection.

Since the multiple causes of disease processes exist in the community,

in the household, and in the occupational environment, they may be and have been opposed by specific measures applicable against the agent, the host, and the environment. Certain agents are attacked by water purification, sewage disposal, burial of radioactive material, machine shields, food supplements, ultraviolet light, noxious-vapor control, etc. The causes in many may be opposed through immunization, improvement of nutritional habits, stimulation of proper personal hygienic attitudes, the use of suppressive drugs,[22] and the use of protective clothing and masks in industry. Environmental factors in addition to those already mentioned may be counteracted by swamp drainage, housing improvement, the control of disease vectors, and the amelioration of deleterious socioeconomic factors.

Secondary Prevention

EARLY DIAGNOSIS AND PROMPT TREATMENT The obvious objectives of early diagnosis and prompt treatment are (*a*) to prevent spread to others if the disease is a communicable one; (*b*) to cure or arrest the disease process in order to *prevent* complications or sequelae; and (*c*) to *prevent* prolonged disability. *Case finding* in the early stage of disease, when treatment is most effective, has been the basic principle of modern syphilis- and tuberculosis-control programs and now has become an important aspect of control of chronic diseases and cancer. Early diagnosis of and proper attention to nutritional, mental, allergic, and other disorders has proved the effectiveness of attack on the natural history of these conditions at this clinical level.[23]

Health promotion is not applied for specific disease and as yet is not widely utilized, and specific protective measures for many conditions are, so far, unknown; but prevention by early diagnosis and prompt treatment has received concentrated attention in medical and dental education for many years. Adoption by the medical and dental professions of a positive program of preventive medicine for the individual, including periodic selective examination, should bring large groups of the population within the scope of this level of prevention (Chap. 15).

Prevention by early diagnosis and prompt treatment may be effectively illustrated by reference to the natural history of syphilis [10] and the change in the syphilis problem over the past several years. There can be little doubt that the present state of syphilis control results from a widespread application of early diagnosis and prompt treatment. One would not minimize the value of health-promotional activities, such as sex education and the improvement of socioeconomic conditions, in preventing a certain number of cases of syphilis, nor would one question the effectiveness of prophylactic measures applied at the time of exposure in preventing a number of syphilis infections. The success of the syphilis-control program,

however, has depended largely on finding cases in the earliest stages, on prompt and adequate treatment, and on contact investigation in order to bring other cases under observation as early in the clinical process as possible. These control measures are preventive not only for the patient himself, who thereby escapes progression of the disease, but also for others who are protected against exposure to the infective agent.

Some diseases, such as dental fluorosis (mottled enamel), do not become manifest until the pathologic process has run its course. The earliest sign of this disease, by present methods of detection, is apparent only when the condition is fixed and no remedial measures can be applied. However, the detection of dental fluorosis may lead to treatment of the water supply in a community and the eventual prevention of the disease in others (Chap. 10).

Tertiary Prevention (Disability Limitation and Rehabilitation)

DISABILITY LIMITATION This level includes prevention or delaying of the consequences of clinically advanced disease. Only delayed recognition due to incomplete knowledge of disease processes serves to separate this level of prevention from the previous level. The preventive aspects at this stage of disease development involve treatment of a more or less advanced disease process.[24] The fact that the departure from a state of health has been so extreme points to the failure of prevention at some earlier phase in the natural history of the disorder. The many persons coming to medical attention with advanced detectable disease emphasize the need for the medical and dental professions to apply existing knowledge on a wider scale for the prevention of disease. It is also imperative to continue clinical, laboratory, and epidemiologic research that will expand the horizon of clinical detection, so that disease may be discovered earlier in its development. This is of particular importance in chronic disorders, such as cardiovascular-renal disease and arthritis, and in the morbid conditions associated with the aging process. The need for prevention at earlier levels than is now possible is presented in Chap. 7.

In this late level of disease prevention certain economic environmental changes may aid in preventing sequelae, but the preventive measures are primarily therapeutic, directed toward the host in order to arrest the disease process and to prevent further complications or sequelae. The questions which should invariably arise in the mind of the doctor treating such advanced cases are: What circumstances permitted this individual to reach such an advanced stage of this disorder? What might have been done to interrupt the progress at an earlier period? The answers may be accusatory, in that they may point to the failure of the doctor or his community to apply the knowledge at hand, or they may be provocative in that they stimulate a desire to explore some of the unknown factors in the natural history of disease so that new preventive measures may be devised for earlier interruption of disease processes of this kind.

REHABILITATION This is more than stopping a disease process; it is also the prevention of complete disability after anatomic and physiologic changes are more or less stabilized. Its positive objective is to return the affected individual to a useful place in society and make maximum use of his remaining capacities. In many of the ailments that affect man, measures are lacking for specific protection and for disability limitation by medical treatment, so medicine must depend on rehabilitation to teach those afflicted to live and to work as effectively as possible. Rehabilitation has its physical, mental, and social components. It is based on an underlying principle of preventive medicine—that the doctor's responsibility goes beyond just medical or surgical treatment of illness. This responsibility begins before illness develops and ends only when the disabled patient has been trained in such a manner that he can live and work with what he has left. Few will deny that this constitutes a phase of the doctor's responsibility.

As presented in Chap. 16, successful rehabilitation depends on adequate facilities in hospitals, the community, and industry. It entails, among other things, selective placement, satisfaction of full-employment potentials, work therapy in hospitals, and the use of sheltered colonies in some instances.

The present concept places the features of health promotion and disease prevention in a framework based on the natural history of illness. It is a first step in bringing all those interested in health to a common point of departure for their own specific contribution to man's health and welfare. Its foundations lie in the evaluation of health on a graded scale and in the concept that departure from health to disease is a process involving the interaction of disease agents, man, and the conditions and characteristics of the environment. The evolution of each specific disorder of man follows a more or less constant process, arising before man is involved, which may be termed the natural history of the disorder. It is clear that knowledge may be lacking of many of the links in the chain of causation and effects which contribute to a particular natural history; but practical application of preventive measures at one or another level need not await complete knowledge of *all* causes and effects.

Figure 5 shows diagrammatically the interrelationships of the practice of preventive medicine, the natural history of disease, and the levels of prevention. The top section (definition and practice of preventive medi-

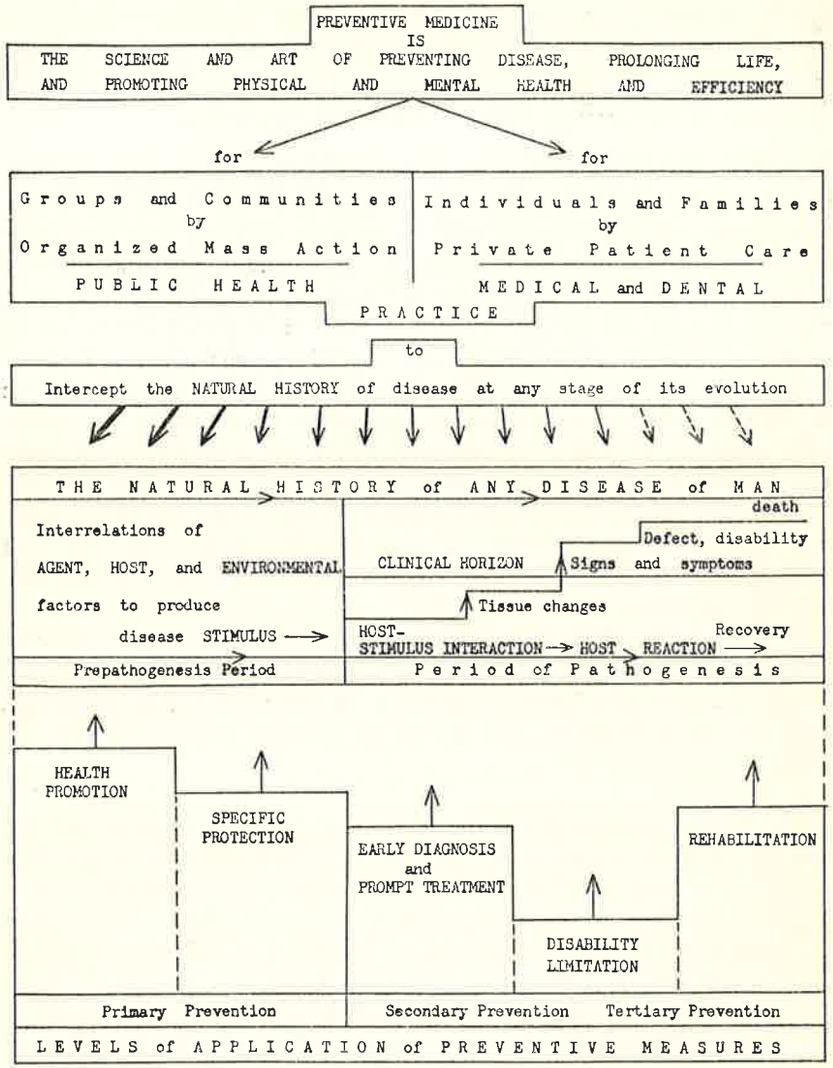


FIG. 5. Diagram showing the application of preventive medicine—the relationship of Figs. 1, 2, and 4.

cine, from Fig. 1) indicates the basic unity of private practice and public health.[11] The central part (natural history of any disease, from Fig. 2) shows the nature of the disease problems requiring attention.[3, 10] The lower part (levels of prevention, from Fig. 4) demonstrates the points of possible attack by those interested in preventive medicine. This epidemiologic concept as shown in Fig. 5 reveals the common objective of public health and medical and dental practice and emphasizes the necessity for teamwork in the services of health.[7]

Figures 6A and 6B give a specific illustration of the application of the epidemiologic concept of natural history and related levels of prevention to acquired syphilis.[10]

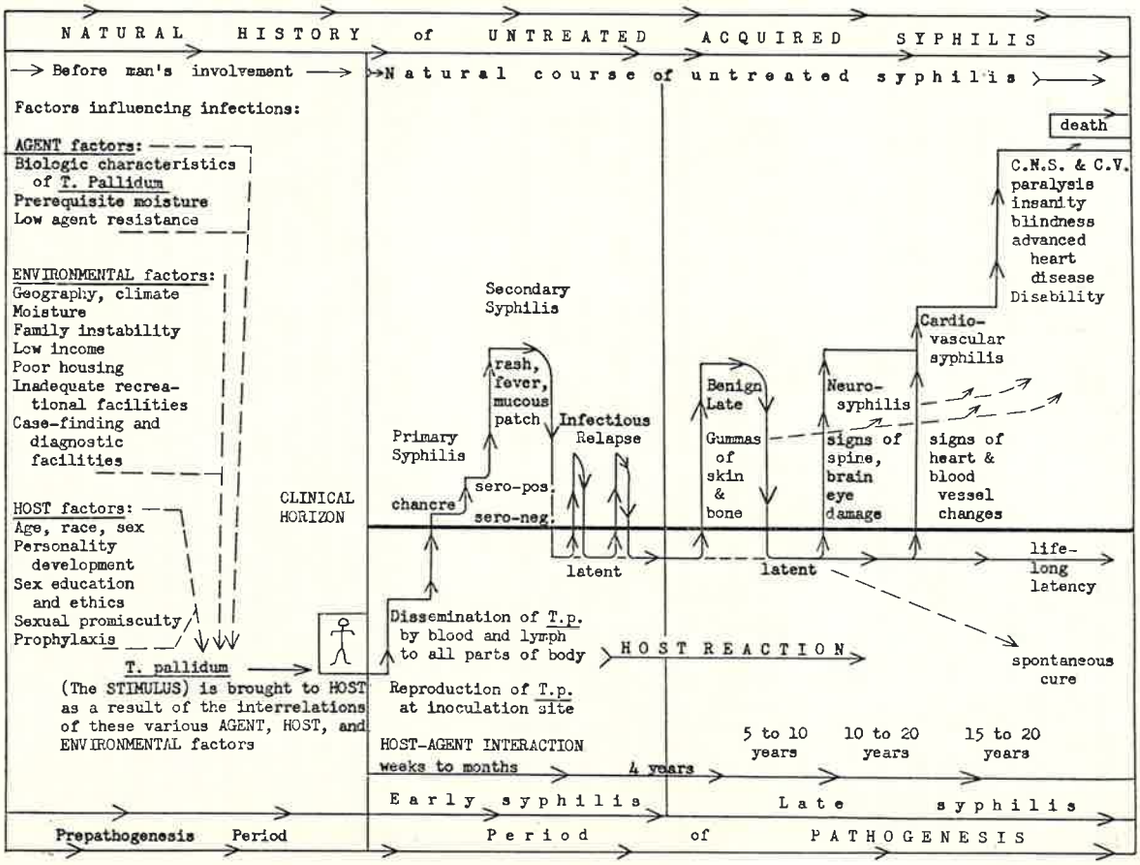
THE NATURAL HISTORY OF SYPHILIS AND LEVELS OF PREVENTION

An understanding of the biologic characteristics of the treponemal agent of syphilis and of the reactions of the human host to it has added much to the knowledge of this disease pattern that has aided in its prevention and control. Yet, for its eradication or its reduction to minimal importance in the United States and throughout the world, a consideration of outstanding environmental factors must be taken into account.

Natural History

Figure 6A, following the pattern of Fig. 2, shows the natural history of syphilis as defined on page 16. The specific microorganism reaches the biologic orbit of man through the interaction of a variety of host and environmental factors during the prepathogenesis period. Whether or not man becomes infected depends on the biologic characteristics of this microorganism, the habits and defense mechanisms of man relating to them, and the status of certain important environmental factors.[12]

The period of pathogenesis, after infection takes place, is illustrated by a graph,[13] the vertical axis denoting the extent of the disease process and the horizontal signifying time. The heavy line indicating the division between symptomatic and asymptomatic stages is the *clinical horizon*. Syphilis as it progresses (as shown by the steps of the graph line) may be symptomatic (above the clinical horizon) or asymptomatic (below); early (under 4 years' duration) or late (over 4 years); infectious (primary, secondary, and infectious relapse) or noninfectious (late). There may be "spontaneous cure" or lifelong freedom from symptoms (clinical latency). It may terminate in death, defect, or disability. The levels of application of preventive measures are shown in Fig. 6B.



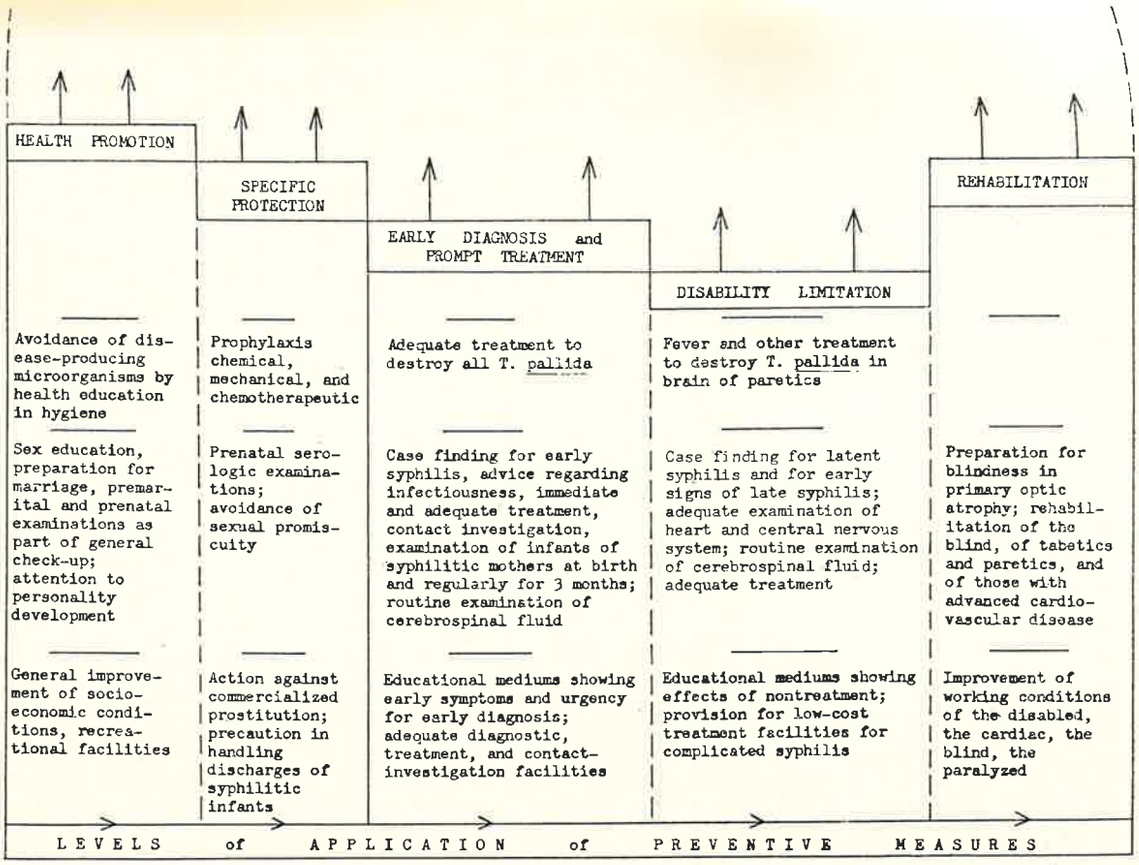


FIG. 6. *Above* (A), the natural history of untreated acquired syphilis; *below* (B), levels of prevention based on knowledge of the natural history.

PREPATHOGENESIS PERIOD As in other disorders, the background for syphilis infection is laid long before agent-host relationships begin. In congenital syphilis, the groundwork may be laid before marriage through the acquisition of syphilis by the potential mother or father. It may be affected by absence of premarital examination or by inadequacy of examination and of treatment. It may be conditioned by the attitude of the parents to pregnancy and prenatal care, by extramarital relationships, by lack of knowledge of prophylaxis, etc. Furthermore, the course of congenital syphilis may be related to the cost and availability of medical care at the time of delivery and in the succeeding few months.

The factors involved in acquiring and transmitting syphilis are complex. They have their origins in variations of human behavior, in sexual promiscuity, in marital maladjustments, and in some of the inadequacies of our social and economic life; they are rooted in prudery, ignorance, and defeatism on the part of the public.[14, 15] In the past these attitudes have presented obstacles to the application of the usual methods of control utilized against communicable disease. Great progress has been made in overcoming such attitudes, and much has been accomplished in the control of syphilis. Yet the problem is far from solved, as demonstrated by the annual surveys of the American Social Hygiene Association, the American Venereal Disease Association, and the Association of State and Territorial Health Officers.[16]

Agent Factors The biologic requirements of *Treponema pallidum* explain why syphilis is a disease of intimate contact. This organism is extremely fragile, is unable to resist drying, is unfavorably affected by many common antiseptics, and is said to be destroyed more quickly by soap solution than by many strong disinfectants. It dies under blood-bank conditions in a short period of time but will survive rapid freezing to —76°C. for a year. It is found infective for 26 hours in syphilis autopsy material. It is immobilized at 41°C. in 2 hours. Man is an obligate host; the experimental infections in animals are not persistent. The agent has not been cultivated on artificial media.

These facts have a direct bearing on the behavior of the organism in nature. In more primitive treponematosis [17] (yaws, bejel, and endemic syphilis), the organism found widespread favorable conditions for existence on the moist skin in tropical areas and was spread by close bodily contact as a nonvenereal disease. These propitious conditions were denied the treponeme with the advance of civilization, the move to less humid areas, and the change in the type of clothing. Under these circumstances, only on the mucous membranes about the genitalia and in the mouth are conditions consistently found which permit the survival of *T. pallidum* for periods long enough for invasion. These biologic characteristics therefore determine the reservoir of infection, dictate the means of transmission, and materially affect the host-parasite interaction.

Environmental Factors The influence of any one or any group of these factors cannot be measured with precision, but there is little question that environment, as broadly interpreted here, plays a major role in the initiation and perpetuation of syphilis, and that efforts must be directed toward mitigating the forces of the environment, if prevention is to be successful. Some of the factors are analyzed in the Cooperative Studies in the Social and Educational Aspects of Venereal Disease Control,[14] e.g., the socioeconomic environment and its effects on man. The effect of the physical environment (geography, weather, climate, etc.) on the human host and his relationship with the specific microorganism has been shown by Hudson [17] to have altered the manifestations of the disease under different climatic circumstances to such an extent that patterns of this disease related to morphologically indistinguishable treponemes are given such different names as *endemic syphilis, yaws, bejel, pinta,* etc.

The cultural elements in the existence and spread of venereal disease in the United States, as discussed by Ennes and his colleagues,[14] are marked by "transient sexual intercourse of a noncommercial variety, family instability, obstacles to early marriage," and to a lesser extent by alcoholism and the "eroticism of modern American advertising." There are "frustrations which come from lack of status and which accompany social and economic inequalities." The ethical aspects have to do with the lack of a strong pattern of sex ethics which "strikes a reasonable balance between the facts of modern life and the wisdom of the past."

There is little doubt that the personality of an individual (a host factor) influences his behavior, as discussed in Chap. 13. Personality, in its turn, is the product of many pressures and environmental circumstances.

There is general agreement that the social environment may be particularly conducive to the spread of infection. For example, low income, poor housing, and inadequate recreational opportunity all contribute to the perpetuation of syphilis in a community. The success of organized community control depends on the extent and availability of public health facilities, the adequacy of case finding and case holding, the "index of suspicion" of medical agencies, the availability of laboratory services, the extent of contact investigation, and the application of premarital and prenatal examination procedures.

It was generally believed among the respondents in the sociologic studies cited above [14, 15] that prevention and control depend on proper attention to the previously mentioned causes and to the extension of general health education, sex education, legal control in terms of law enforcement and repression of prostitution, and more accessible and adequate facilities in public health. It was pointed out that health education

"is a primary field of action, for ignorance is significant in predisposing to infection," and that

> . . . biologic illiteracy accounts for much venereal disease. Parents have been lax in meeting their responsibilities and themselves are not informed. The schools have been negligent and must take a far more active role. Context of sex education, however, is not physiologic or mechanistic, but that of health and human relations education which takes into account physical, emotional and social development.

Host Factors Some of these factors have been mentioned in connection with agent and environmental factors: habits, customs, attitudes, personality development, sex education, use of prophylaxis, etc. Man is the sole reservoir of syphilis infection. In nature syphilis has been found only in the human species. Infection can be transmitted artificially to certain animals, but it dies out spontaneously without transmission to others of the same species. Whether man as the reservoir of the disease transmits it to others depends on (*a*) the outcome of the complicated host-agent interaction, (*b*) the habits and customs of the host. In view of the fact that the viability of this microorganism depends on moisture, the chance of exposure to it is dependent on intimacy of contact, sexual behavior of the host, and habits in respect to prophylaxis. When the infected moist secretion of the diseased host comes into relationship with a new host, (*a*) the organism may fail to gain access and lodgment; (*b*) it may gain access, lodge, multiply, and produce infection without early clinically discernible tissue reaction (symptomless infection); or (*c*) it may gain access, lodge, multiply, and produce the characteristic discernible reactions of early syphilis.

PERIOD OF PATHOGENESIS Host-Agent Interaction After the treponeme has gained admission to and settled in tissues, there is reproduction at the inoculation site. Dissemination from the portal of entry by means of the lymph and blood streams occurs within several hours, with the result that prophylaxis delayed longer than this time, even if it goes to the extent of excision of the inoculation site, will not prevent disease. Syphilis is a generalized infection almost from the beginning, the organism being carried from the original entry site to all tissues of the body by means of the blood stream as a passive carrier. Thus it is possible for the organism to be transmitted to another host by blood transfusion before there is any clinical or serologic evidence of infection in the infected donor. The blood-stream spread of the treponeme during this early incubation period probably lays the foundation for all the late manifestations.

After a variable incubation period ranging from 10 days to 10 weeks (average 3 weeks), the first manifest lesion of the disease appears; it is portrayed in Fig. 6A by steps of the graph line reaching the clinical horizon. This is primary syphilis, and at the time of the appearance of the chancre the serologic test is usually negative. It is important to remember that although in most instances infection is followed by visible tissue reaction at the inoculation site, and generalized tissue reactions usually follow the dissemination of the organism, either or both of these phenomena may fail to occur or be so slight as to evade notice. Infection may progress without any demonstrable lesions. The precise mechanism operating to suppress the visible early reaction is not well understood; it may depend on a single factor or a combination of factors such as the size of the infective dose, the site of the inoculation, the age of the patient, the hormonal influence of sex or pregnancy, or the administration of penicillin during the incubation period for prophylaxis or for the therapy of some other disorder.

The mild, superficial, nondestructive primary lesion enlarges and is usually followed by a painless swelling of the regional lymph nodes. Soon antibodies can be detected in the blood, and the serologic test results become positive. Over the next 4 to 6 weeks or longer, even without specific treatment, the chancre begins to involute spontaneously, and the results of the earlier blood-stream dissemination and subsequent reproduction of the treponeme may become manifest in generalized lesions on the skin and mucosal surfaces—the secondary outbreak. During this secondary stage there may occur also a mild or moderate constitutional reaction characterized by malaise, general lymphadenopathy, or other manifestations of toxemia. These and the clinical lesions persist for a variable period of time ranging from a few days to several months and in their turn disappear spontaneously, as shown in Fig. 6A by the line falling below the clinical horizon. These early lesions of syphilis are characterized by a mild tissue reaction and the presence of large numbers of *T. pallidum*. They are superficial, nondestructive, highly infectious lesions and usually heal without scarring. With healing, the treponemes usually disappear from the skin and mucous surfaces.

After this, an indeterminable period of clinical latency (from weeks to years) follows without outward signs of infection; during this period the infected individual is recognized as syphilitic only by means of a positive reaction to the serologic blood test. The latent period may be interrupted during the first few years by recurrences of infectious lesions representing renewed treponemal aggressiveness—secondary relapse or recurrences in skin, mucous membranes, eye, or central nervous system. After an unpredictable number of years, late, noninfectious tissue reactions may occur in the skin, mucous membranes, and cardiovascular, nervous, and other systems. This agent-host interaction represents a biologic struggle between the aggression of the treponeme on the one hand and the resistance of the host on the other, one attempting to overcome the other. The biologic

struggle over the years may result in a more or less symbiotic relationship between these two living organisms, with the result that in a large proportion of instances man's health is not impaired.[18, 19] This does not mean that effort should not be expended to improve the chances of the host, since it is not possible to predict in which direction the balance of the opposing forces will swing. Thus, the agent-host relationship may end in "spontaneous cure"; in a condition of lifelong latency, the only evidence of syphilis being a positive result of the serologic blood test; or, in a smaller proportion of cases, in reactions in the skin, mucous membranes, cardiovascular, nervous, or other systems.

In the study of untreated syphilis in Oslo, Norway,[18, 19] a high proportion of untreated syphilitic persons had no serious ill effects, but 30 per cent showed late manifestations of the cardiovascular and central nervous systems and 10.8 per cent died as a result of the disease. Furthermore, the secondary relapse rate was high (25 per cent), and doubtless much conjugal and congenital syphilis resulted.

There is no natural immunity to syphilis in man. The host reacts to the presence of the organism by developing a state of acquired immunity or resistance which influences the spontaneous healing of early lesions, protects against new organisms introduced from without, withstands to a variable degree the aggressiveness of the organisms present in the tissues, and in approximately 70 per cent of cases maintains clinical latency throughout life (including spontaneous cure).[18, 19] There is some evidence that such factors as sex, pregnancy, race, and constitution affect this host-parasite relationship.

The transmission of syphilis depends on certain conditions of the agent-host reaction, on satisfying the biologic requirements of the microorganism, and on certain habits and customs of the host. Thus for transmission it is necessary that the organism (*a*) escape from the infected host in sufficient numbers; (*b*) be appropriately transmitted under conditions which satisfy its biologic requirements; (*c*) gain access by finding appropriate portals of entry in the new host. Moist surfaces provide the avenues by which the organisms escape from the reservoir, and intimate contact, usually by sexual intercourse, furnishes the conditions necessary for conveyance to a corresponding portal of entry in a new host. The newly implanted microorganism becomes established under conditions of moisture and warmth lasting long enough to enable it to penetrate host barriers.

Infectious moist lesions are present only during primary, secondary, and recurrent secondary syphilis. Body fluids and secretions (saliva, semen, vaginal discharges) from syphilitic persons in various stages of the disease have been studied experimentally and frequently have been shown to

contain the organism during the early stages of syphilis when lesions are present, but only rarely, if ever, during the later stages when there are no obvious lesions. Blood is a passive carrier of the organism and appears to be infective chiefly during the incubation period and while primary and secondary lesions are present. At the present time the accepted explanation of in utero infection is that occasional spirochetemia occurs and results in the circulatory transfer of organisms to the fetus. This has not been proved experimentally. Intimate contact with primary and secondary lesions provides the most favorable conditions for transmission; however, despite the presence of infectious lesions, transmission following unprotected sexual intercourse does not invariably take place.

Transmissibility, therefore, depends on (*a*) duration of infection; (*b*) presence of moist lesions; (*c*) infectiousness of secretions; (*d*) tissue reservoirs of organisms; (*e*) intimate contact with the organism in sufficient numbers; and (*f*) accessible portals of entry in a susceptible individual which satisfy the biologic requirements of the organism.

Levels of Prevention

These are shown in Fig. 6*B* as they may be applied during the natural history of syphilis. The multiple causes of syphilis contributing to its natural history make it necessary to take into account the many forces that operate before as well as after pathogenesis begins in the individual. It is necessary that preventive action be directed against the agent, the host, and the environment at each of the levels of prevention in so far as present knowledge will permit.

HEALTH PROMOTION As in other disorders, health-promotion measures may have a specific effect on syphilis, but they are undertaken to further general health and well-being. For example sex education has a general effect by favorably influencing marital adjustment and thereby promoting health. Specifically, it should have an effect on exposures to syphilis.

SPECIFIC PROTECTION Prophylaxis, prenatal examinations, and efforts against commercialized prostitution have a specific protective effect and constitute the only specific measures available in the absence of means of immunization.

EARLY DIAGNOSIS AND PROMPT TREATMENT Early diagnosis and prompt treatment have been the basic principles of syphilis control over the years. The procedures involved are shown in part in Fig. 6*B*.

DISABILITY LIMITATION The case-finding measures for latent syphilis bring many persons to a treatment which will assure prevention of disability and even its limitation in instances of advanced tertiary syphilis.

REHABILITATION The syphilitic blind and the syphilis patients with cardiac conditions or paralysis are no longer in a hopeless situation if this level is applied to prevent total disability.

There is no doubt that much has been accomplished in syphilis control and that there is considerable optimism in respect to its eventual elimination. Nevertheless, there are still many gaps in knowledge which stand in the way of complete eradication of this disease. For example, *T. pallidum* has not yet been cultivated on artificial media; there is no immunizing agent; very little is known about the mechanisms contributing to the natural history of untreated infections, about the duration of infectiousness, the mechanism of immunity, the mechanism of infection in utero, the selectivity of the microorganism for certain tissues, or the nature of reagin, upon which serologic tests are based. Furthermore, to those who subscribe to the concept that yaws, bejel, pinta, etc., are different clinical entities of the same disease—the view of treponematosis elucidated by Hudson and others—it is "an illusion to hope for a syphilis-free civilization, while yaws remains rampant in the world." [17]

The gaps in knowledge and the evidence [16] of uncontrolled syphilis in many local areas are ample warnings that vigilance must not be relaxed. This is not the time for complete demobilization of the syphilis-control forces but for accurate reassessment of the problem in all parts of the world and continued vigilance everywhere, especially in areas of greatest potential hazard.

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