SYSTEM MODELS IN THE HEALTH SCIENCES

Norman F. White

McMaster University Faculty of Health Sciences

Hamilton, Ontario, L8N 3Z5

ABSTRACT

In the health sciences, concepts are shifting toward system models which recognize multiple factors interacting to determine health phenomena. The hybrid biomedical disease model has proven insufficient for the analysis of modern health problems. A population perspective and an expansion in the influence of the behavioral and social sciences have required conceptual models with greater breadth, and facility in relations between models. Morbidity is portrayed here as two domains of phenomena, the disease process and the illness state, each seen as part of a socio-ecological dynamic. Applied to major disease problems, the utility of these propositions can be examined. In the McMaster M.D. Program, this set of models has been translated into a curricular structure which has the individual in all her/his healthy or morbid aspects as the interface between biological and social systems. Perplexing dilemmas in health care thus become not only understandable but predictable. Adopting this approach creates a new generation of problems. Just as our students have become familiar with the critical appraisal of evidence, the testing of conceptual models becomes a necessary skill. The background to this analysis is the socio-ecological niche of concepts. A model of models is proposed in which concepts interact with problem environments and modern medicine emerges as a case study for socio-ecological epistemology.

Concepts in Medicine

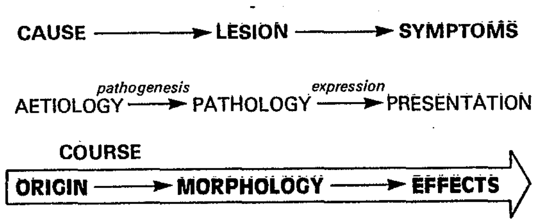
A major shift is occurring in the conceptual basis of the Health Sciences. Its degree, scope and speed suggest the term 'revolution', and its effects promise to be as seismic as the development of the antibiotics. The student of health issues now needs a repertoire of conceptual models which recognize the several factors interacting to determine all health phenomena. Because of the complex relationships involved, the models have a systems configuration, and the properties of systems have become an important issue. Feedback and interaction are not new ideas in medicine, but the self-regulation principles familiar in homeostasis and endocrine axes have been elaborated to include all body systems and social systems. Health care strategies, medical education and research are being significantly influenced by both the character and the variety of these emerging concepts.

In physicianly discourse, 'concept' is used as a summary label for theories, deeply believed but often unsubstantiated 'facts', and widely applied principles. It is generally held that the theories and propositions which support health care practices are to a greater or lesser degree 'true', and that good science, which is seen as the progressive accumulation of fact, brings them ever closer to the truth. Questionning the assumptions and logical structure of the resulting factual edifice is regarded as a self indulgence which gives way to professional maturity, and is dismissed condescendingly as 'philosophy'. In an informal (uncontrolled, non-random, biased, but so far uncontested) survey, final phase medical students were asked to state the ideas out of which clinical decisions and health policies emerge. A few ventured opinions about what 'disease' is. A better response would have been to describe the properties and boundaries of that entity, and to

account for its origins and consequences; none was able to do that. A substantial proportion seemed to interpret the question as a test of faith, and recited some version of the W.H.O. definition of 'health'. This state of affairs is fascinating and disturbing, because there <u>is</u> such a conceptual model. For a new physician to be unaware of it is a little like a graduating engineer being unable to state the Second Law of Thermodynamics or the relationship between force, mass, and acceleration.

The concept most often goes by the label of 'the medical model', and the history of modern biomedicine is largely the story of its evolution. It is half of a dual foundation of the medical enterprise; but, significantly, it is always implicit. However, we should not be too hard on the students; few of their teachers could answer the question and, although the model is assumed, alluded to, criticized, defended, modified and expanded, it is never depicted [1,2].

At its centre is the <u>lesion</u>, which is the 'pathology' of disordered tissue, chemistry or physiology. It is ontogenetically separate from the organism, and its origin, morphology, and effects constitute the characteristics of a disease. Not only does the lesion have an existence discrete from that of the organism in which it is found, but the influences bringing it into being (infection, trauma, neoplasm, degeneration) are seen to be 'external' to the healthy function of the organism. The lesion arises from these agencies, or causes, or aetiologies, through a process of 'pathogenesis' [1]. This is the Biomedical Disease Model (BDM).



The disease process

Yoked to the BDM, as the other half of the conceptual foundation of medicine, is a view of 'health' which supposes that there are conditions to be enhanced, promoted, or preserved, which are unrelated to disease. The most influential definition of health corresponding to this view occurs in the Preamble to Constitution of the World Health Organization;

> ...a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity...

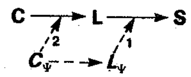
Despite its rhetorical appeal, none of the attempts to operationalize such a Positive Health Model (PHM) has been very successful. Differences of degree in well-being become subspecies of morbidity; and, coupled with the BDM, anything short of complete well-being, by whatever name, is kin to

disease. Although the W.H.O. definition is criticized for being excessively utopian, its principal flaw is that its goals are practicably unspecifiable.

Together, the PHM and BDM provide the conventional underpinnings of modern medicine, and they have been enormously useful. The BDM, also known as the 'germ theory', has ordered a century of data, and was largely responsible for the explosion of biomedical technology following World War II. The W.H.O. definition of health has shown remarkable political durability, and has permitted the implementation of humane programmes under geo-political circumstances where only the 'health' label made them possible. However, this conceptual partnership has been applied so widely that we are approaching the limits to its utility. Two developments have taken place: we have employed these concepts beyond their competence, and their application has actually altered their human biological context. There are well-known examples of both developments: first, medical solutions to several behavioural problems, such as addiction, obesity, and criminality have expensively and painfully eluded us; second, the antibiotics have contributed to increases and change in the age structure of populations, so that health problems differ from those which preceded the antimicrobial therapies.

Variations on a Biomedical Theme

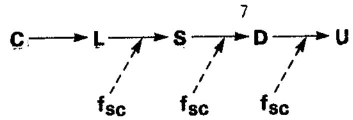
Successive modifications to the BDM have been necessary to account for exceptions to the basic model, and to accommodate discoveries. The most conspicuous problem with the BDM is the irregularity of symptoms, including the frequent occurrence of symptoms without lesions. This gave rise to the psychosomatic variant.



The psychosomatic variant

Here the 'lesion', and sometimes the 'cause', are found in the psyche. An explanation for symptoms without lesions was Freud's point of departure and the origin of psychodynamic psychiatry. Despite broad cultural influence, its clinical performance has been poor. The evolution of this conceptual variant has gone from exclusively intrapsychic factors (such as 'conflicts') to more environmental (such as 'stress') factors. Its ultimate form is the 'biopsychosocial' view of ill health, combining terms and relations from other variants [3].

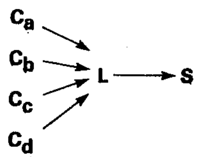
A related variant, the socio-cultural, has had the twin purpose of explaining variations in the manifestation of sickness and in health service utilization. It is sometimes combined loosely with the psychosomatic variant into a hybrid 'psychosocial model'. It provides uneasy accommodation for the 'sick role' concept, the 'illness behaviour' concept, and ethnomedicine [4,5,6,7].



The socio-cultural variant

Here there are no 'lesions' or 'causes' but, rather, a series of interactions in parallel to the disease process. They are not subject to 'treatment' and are distinctly environmental.

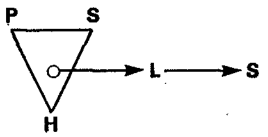
The observation that the same 'cause' may result in different lesions and that the same lesion does not regularly arise from a supposed cause, has given rise to the multifactorial or multicausal variant.



The multifactoral or multicausal variant

Here, 'causes' act in varying proportions and combinations, neither simultaneously nor sequentially, and more or less additively.

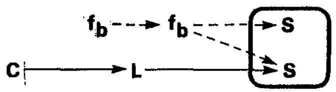
During the 1920's, an ecological variant was proposed by Jacques May who had observed that Indo-Chinese rice farmers developed Schistosomiasis at a far greater rate than their silk-farming co-villagers [8]. The parasite causing this disease spent part of its life in a snail living in the rice paddies. Here, disease is seen as originating in an interaction between the victim host, the infecting agent, and the conditions of the environment which bring them together.



The ecological variant

Also called the 'tropical medicine' or 'public health' model, it has led to the study of host resistance and of the environment as a disease determinant.

The <u>behavioural</u> variant, based in learning theory and social psychology, is addressed primarily to symptom variablity and to symptoms without lesions.



The behavioural variant

Here, symptoms (subjective states) and performance deficits (disability) are seen as behaviours which are altered, or generated, through learning.

In practice, the BDM, modified by the principal features of each of these variants, is still woven through most health care thinking. Behavioural, social and environmental influences are acknowledged, but are seen to exist outside of the central linear causal sequence which proceeds from cause to lesion to symptom. However, there are important health problems which cannot be understood employing this view [9]. Contrary to predictions from the rationale underlying health care systems in the industrialized countries, neither cost nor morbidity has diminished dramatically in response to the distribution of biomedical technologies across societies [10,11,12]. To some extent, this results from the creation of a survivor population, but it is also due to morbidity and supply/demand relationships behaving differently from what had been expected, when measures (models) that practitioners believe effective for individuals are simply multiplied into large scale intervention strategies [13,14,15]. A shift of focus from the individual to populations has been spurred by the increasing importance of chronic, slowly developing, multifactorial diseases. These clearly do not have single causes; several 'determinants' interact over many years. To reach useful conclusions about such multiple, and interacting, determinants requires the study of large groups over long periods of time [16].

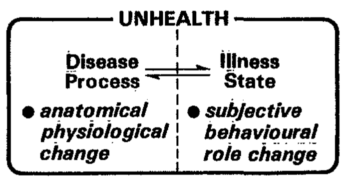
We have also witnessed a huge expansion in the influence of the behavioural and social sciences. Populations obviously cannot be studied without taking into account social and cultural variables, but there are also problems at the clinical level. Thirty to eighty per cent of the complaints seen by physicians are pathologically inexplicable, and eligible for a collection of such diagnostic ciphers as 'functional' 'psychosomatic', or 'stress-related'. The 'clinical art', it is supposed, enables the physician to contend with the irregularity of symptoms [17]. It is about as consistent as most intuitive processes, and is not much improved by the addition of psychiatry. There have been stubborn theoretical problems in both practice and planning: psychogenesis and system abuse ('overutilization') are weak and misleading constructs.

The Dual Nature of Morbidity

Considering the influence of social and behavioural factors upon both the origins of sickness and the forms sickness takes has led us away from a unidimensional view of sickness, or 'morbidity'. Medical sociology and medical anthropology have long found it useful to distinguish between the pathological process of 'disease' proper (e.g., the liver damage and metabolic changes occurring with Hepatitis), and the 'illness' which consists of the sufferer's perception of the disease and the role changes which occur because of it. The factors which influence the development of disease differ from those which affect illness.

Over the last decade, the distinction has been sharpened by the demonstration that subjective states (i.e., experiences, sensations and symptoms) can be manipulated by environmental and behavioural means [18,19]. This has resulted in a model of morbidity which portrays the whole realm of unhealth or

sickness as comprised of the disease process (anatomical and physiological changes which occur with the development of a lesion) and the illness state (symptoms, illness behaviours, and role changes which occur with disease or with the belief that disease is present). Substantial experimental, clinical and epidemiological evidence indicates that the intervention strategies required for the two are dissimilar. These are two domains of phenomena; the distinction is not intended to separate 'real sickness' from 'psychogenic' or imagined sickness. The two most often coexist, but either can (and frequently does) exist without the other.



The interaction between person and environment which results in one is different from that which results in the other: the disease process comes about through a biophysiological interaction between the cells, organs, and systems of the body, and the physical environment; the illness state comes about through the socio-behavioural interactions between a feeling, perceiving, thinking and behaving organism and its social environment. The first process can be summarized as 'pathogenesis'; the second as 'learning'.

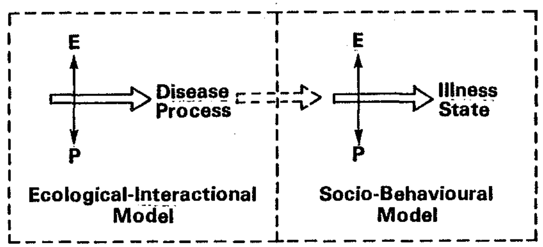
Having made the disease process/illness state distinction, we must account for each. For the disease process, we may consider an ecological-interactional model (EIM), which portrays multiple factors in a human ecosystem interacting with each other and with a person. Within this system, a set of interactions is specifically related to a disease process outcome. In Chronic Obstructive Lung Disease, e.g., lung tissue is the interface between the atmosphere and interrelated body sub-systems (respiratory, circulatory, immune). The quality of breathed air results from climate, pollinating flora, work conditions and smoking. The internal sub-systems have their contacts with the external milieu through diet, physical demands, and microorganisms.

A view of the illness state as phenomenologically and ontogenetically separable from the disease process, and with subjective states, behaviours and role changes derived from the social environments is the socio-behavioural model (SBM).

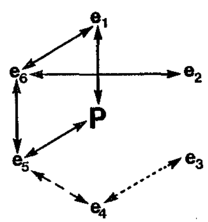
In both cases, sub-systems in the human organism interact with systems in the human environment. Advocates for a unified theory of health and disease point out that it is the same organism and the same environment. It is also true that there are physiological elements operating in the genesis of the illness state, and important behavioural constituents of the disease process. Moreover, the two aspects of morbidity influence each other: disease process is one factor contributing to the illness state (tissue damage, for example,

is obviously related to pain in many circumstances); and the illness state affects disease process through maladaptive health behaviours, impact on immune systems, and psychophysiology. The combination of the two can be referred to as a socio-ecological model (SEM).

Socio-Ecological Model



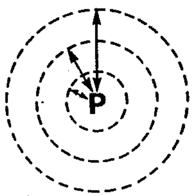
The overall model is based on the view that an organism's total 'behaviour' (i.e., not simply what it does, but everything which occurs within it) is a function of its interaction with its environment (B=f[OE]). An ecological view of the human organism's interactions with the environment understands those interactions to be with interrelated social and physical elements.



Ecosystem interactions

Here 'P' (the person) is one of many interdependent elements. To apprehend the outcomes of this of interaction, we apply systems principles: the system as a whole has properties which are not reducible to the properties of any single constituent; the function of any single element is affected by the operation of the system as a whole; and change in any point of the system can be predicted to have remote effects. This changes our view of causation. A 'caused' outcome requires a number of preceding events which are not linear.

Sometimes, when it is convenient to identify a single 'causal' element, We may distinguish between <u>proximal</u> and <u>distal</u> determinant-causes.



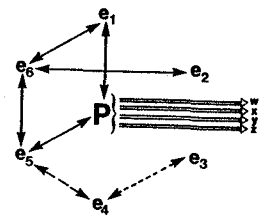
Proximal and distal 'causes'

In health care, we are traditionally most familiar with the proximal causes and, not surprisingly, our conventional disease models are best suited to them. More modern disease problems, as viewed in a population or behavioural perspective, require us to contend with intermediate and distal causation.

Some examples are; are;

	PROXIMAL	INTERMEDIATE	DISTAL
LUNG CANCER	CARCINOGENIC TARS	SMOKING BEHAVIOR	SOCIAL PRESSURES
T.B.	TUBERCLE BACILLUS	NUTRITION/HYGIENE	INDUSTRIAL REV'N
BEHAVIOR	CONDITIONING	SOCIAL SETTING	CULTURE

Judgements about which outcomes of a person-ecosystem interaction are undesirable, and about which of these should be regarded as 'unhealth', are determined by socio-cultural factors. We may use scientific method to study the phenomena upon which we base such judgements, but the judgements themselves are dialectical, not technical.



In our culture, the key factor influencing the decision about 'what sickness is' appears to be the institution we wish to have responsibility for it. That is, some of outcomes w,x,y,z are identified as 'health problems' because our society wants medicine to look after them.

<u>Critical Appraisal of Conceptual Models</u>

The origins of this model, as outlined above, were in the increasing failure of multiply-modified disease models to account for important phenomena, and the inappropriateness of these models for the planning of modern health care interventions. Setting this new formulation alongside conventional conceptual models raises some interesting questions: Can we tell whether this model is superior to those it is proposed to supplant? If it is superior, was the old model always 'wrong'? What are the consequences we might expect from the widespread adoption of this model?

Merely proposing an alternative conceptual framework has some interesting impacts and implications. Suggesting a degree of choice in how we assemble information collides with the notion of absolute 'truth'. To imply that we can design these ideational structures also implies purposes and specifications underlying the design, and that its success may be judged [20]. Within the context of the purposes for which it is constructed, the conceptual model can be appraised with respect to its clarity, comprehensiveness, correspondence to related models, and utility. This last is, of course, the ultimate test, and there are subcategories of utility: heuristic, predictive, praxeological, and sociological [21]. The importance of appraising the quality of evidence has become an accepted principle [22,23], but we must now also test the non-evidential component of claims and propositions.

The application of the SEM to two major health problems, Infantile Diarrhoea and Coronary Heart Disease, illustrates how

such appraisal might be directed. The magnitude of the Coronary Heart Disease problem in the industrialized countries is well documented. Smoking, diet, lack of exercise, stress, hypertension, gender and genetics have been identified as its major determinants (we no longer speak comfortably of 'causes'). The disease process consists, e.g., of abnormal blood vessels, damaged heart muscle, enzyme changes, clots, and conduction abnormalities. The chain of events leading to each of these abnormalities either is already explicable in biophysiological terms, or in principle can be. The illness state in a person having suffered a heart attack consists of chest pain, weakness, fatigue, and general malaise. It also includes the fear, loss of confidence, dependence upon physicians, and interruption of normal activities. Besides these behaviours, there are special roles assigned to the coronary patient which entail the gain of some privileges and the loss of others. Patients with the same degree of coronary exhibit widely varying disibility, and this variation is relatively inaccessible to medical treatment. The affective-cognitive-behavioural sub-systems which, in interaction with the socio-cultural environment, are responsible can be influenced through methods based in learning theory and social psychology. When the socio-behavioural dynamic of the illness state is approached as if it were disease(-like), the result is often increased morbidity through unnecessary medication or exaggeration of the sick role. The hazards of applying a socio-behavioural strategy to the biophysiological dynamic of the disease process are even more obvious: it is yet to be demonstrated that we can alter clotting times through persuasion.

While the final events leading to the lesion in CHD are biophysiological, it is clear that the earliest events are behavioural and social. Damage done by the combustion of tobacco begins with the socio-cultural determination of smoking behaviour. Whatever lipid havoc is wreaked on vessel walls begins with dietary habits. Exercise, high intensity life styles, and poor compliance with preventive regimens are all behavioural. In the ecology of this disease, behavioural determinants are our main targets in trying to achieve some degree of control. In the illness state, we cannot ignore physiology; arrythmias, for example, are well-known to be triggered by sudden emotional stress.

Infantile Diarrhoea is responsible for about a third of all deaths in children under five in the developing world. International agencies have discovered that introducing clean water is not only expensive but often ineffective. A complex web of behaviours involved with water use, hygiene and child care determine how an infection cycle occurs. Dietary, social and health care customs support these habits and, in turn, are founded in cultural beliefs and socio-economic circumstances. Medical treatment of diagnosed cases is too late, too little and too expensive. What is needed are low-technology

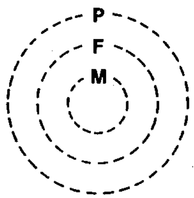
strategies which can be implemented by the people themselves and which are not culturally disruptive. Socio-ecological analysis makes it possible to choose a number of accessible, unobtrusive intervention points which can alter the operation of the community system to reduce a diarrhoeal outcome in a way which suits local needs and resources.

In CHD, there are two major problems of which neither, in the traditional sense, is biomedical: prevention of the disease, and mitigation of distress and dysfunction in those who already have it. The disease process itself, once established, is incurable. In ID, the problem is prevention, but this also has two parts: interruption of a socioecological disease cycle, and appropriate response to identified disease. In both cases, different strategies are needed for the disease processes and the illness states. Moreover, each depends upon adequate analysis of interrelated social, physical and behavioural factors.

Systems Epistemology

A conceptual model, as considered here, is an imagic representation of some part of a natural phenomenon, devised to assist us in understanding the operations of the phenomenon, predicting its course, or manipulating it. We can think of an expanding series of concentric formulations proceeding from small or 'sub-' models through larger models and conceptual frameworks to paradigms and, finally, to a world view or

'Weltanschuung'.



The scope of concepts

For example, we might employ a micro-model of ion transport across the cell membrane in a renal tubule; a larger model accounts for the physiological operations of the kidney; the logical structure within which the 'kidney model' must be understood is homeostasis; the paradigm in which homeostasis finds its home is a cybernetic variant of natural science; and, finally, such paradigms are possible only with certain assumptions about existence, causation, and time. We are usually concerned with the first levels of abstraction, but cannot disregard the impact of paradigm shifts: notions of homeostasis, systems dynamics, and the 'selfish gene', have all had palpable impact on health theorizing. The probablistic view of causation which arose in both small particle physics and biology over the last half-century has affected such matters as how to understand the multifactorial etiology of heart disease [24,25,26,27].

A conceptual model comes into being in response to a problem. Its survival depends upon its degree of 'fit' with a problem environment. Models which breed successful solutions

tend to dominate those which do not. However, as occurs in the relationship between any organism and its environment, the interaction between the model's progeny and the environment changes that environment. As problems are solved, the environment is changed simply by their having been subtracted from it; for example, the increased incidence of the cancers is due almost entirely to the elimination of other life-shortening disease. The health field shows another way in which the problem environment is affected, through the impact of <u>un</u>successful solutions. The misapplication of biomedical strategies to behavioural-existential disorders has, to cite a widely disussed example, resulted in an epidemic of psychotropic drug use. There are also indirect effects, such as the steering of cultural priorities through allocation of resources to technologies.

The more successful a conceptual model, the more certainly and rapidly it will be found interacting with a problem environment different from that for which it was originally devised. To be continued in use, the model must be progressively modified (updated); the existence of unsolved problems and exceptions to the rule must be denied or attributed to factors outside the jurisdiction of the model; special solutions for these new problems must be devised, in a way which is apparently consistent with the model but also separates these problems from it; or a successor to the model must be devised. All of these things have occurred in the recent history of biomedicine. The more completely and quickly a conceptual model is applied in the real world, the more clearly the limits to its utility are discerned. One would also predict, however, that a conceptual model would not lose its utility for the solution of at least some of the problems for which it was originally constructed. This is true also for physics; Newtonian mechanics is still very useful for building a house, and played a large part in getting us to the moon. This model of models portrays a (health) concept as a tool interacting with a system of problems, beliefs, institutions, technologies, and roles. Efforts (as in Kuhn's 'normal science') to keep it static have the same distorting effects one would expect in any system [28]. Changes in any part of the system will, if equilibrium is to be maintained, be reflected by adjustments elsewhere.

Thus, the biomedical disease model was/is not 'wrong', although its utility with respect to the modern problem environment may be less than in its original environment; its future can only be grasped within such an epistemological system.

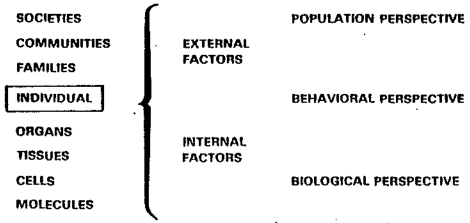
Impacts and Implications

One response to the 'information explosion' in some medical school curricula has been to emphasize "how to learn" over "what to learn". Students learn information management and the critical appraisal of evidence to survive in a sea of data. It is clear, and quite consistent with scientific

tradition, that conceptual fluency is a crucial skill in this information management. Changes in the problem environment brought about by the deployment of biomedical strategies have created the need for a broader repertoire of conceptual tools. Each has its appropriate application; which is to say, each has a unique problem environment, or epistemological system. The student must be able to discriminate between concepts and to judge their performance.

A systems approach has changed our views of causality and of the nature of what we are studying. Simple linear causation is seldom even an acceptable approximation; in the 1950's, a student would have been failed for not saying that the tubercle bacillus is the cause of T.B., and today would be failed for saying that it is. We now have determinants and risk factors, rather than causes. Students learn how to formulate the most useful hypotheses, rather than to have a store of answers. Probabilities dominate facts. Prevention and the avoidance of iatrogenic morbidity do not demand new treatments, but call for attention to the system out of which disease and illness have arisen.

The shift toward a population perspective is more than just epidemiology coming of age. All the manifestations of ill-health - symptoms, emotions, behaviours, roles - are essentially interactional phenomena [29,30,31,32]. Indeed, the individual in all her/his healthy or morbid aspects <u>is</u> the interaction between biophysiological and environmental systems. This organizational model can be seen in the structure of the M.D. curriculum at McMaster University.



The content areas are social-environmental systems ('population perspective') and body systems ('biological perspective'), and the 'behavioural perspective' which is at the interface between them. Studying all individual health, disease and illness phenomena as products of the interaction between body and human ecological systems significantly alters the student's task. It also relocates medicine (or, better, 'health studies') as a sub-set, simultaneously, of human biology, the social and behavioural sciences, and the humanities [33]. Many otherwise perplexing clinical and preventive dilemmas become not only understandable but predictable.

For the relationships between technology, society and ideas, the modern history of biomedicine provides an ideal case study. There probably has never been a combination of technique and concept applied as widely, rapidly and confidently as in the large-scale health systems instituted since WWII. This is where we can learn about both systems as concepts and concepts as systems.

Bibliography

1. White, N.F. Modern health concepts. In: The Health Conundrum: Explorations in Health Studies. OECA: Toronto, 1981
2. Fabrega, H. Disease and Social Behavior: An Interdisciplinary Perspective. MIT: Cambridge, 1974
3. Engel, G.L. The need for a new medical model: a challenge for biomedicine. Science, 1977, 196, 129
4. Fabrega, H. The need for an ethnomedical science. Science, 1975, 189, 969
5. Mechanic, D. Response factors in illness: the study of illness behavior. Social Psychiatry, 1966, 1, 11
6. Parsons, T. Illness and the role of the physician: a sociological perspective. American Journal of Orthopsychiatry, 1951, 21, 452
7. Twaddle, A.C. The concepts of the sick role and illness behavior. Advances in Psychosomatic Medicine, 1972, 8, 162
8. May, J.M. (Ed.) Studies in Disease Ecology. Hafner: New York, 1961
9. Lalonde, M. A New Perspective on the Health of Canadians. Government of Canada: Ottawa, 1974
10. Fox, R.C. The diminishing marginal benefit of high-technology services. In: R.M. Battistella & T.A. Rundall (Eds.) Health Care Policy in a Changing Environment. McCutchan: Berkeley, 1978
11. Kennedy, I. The Unmasking of Medicine. Allen Unwin:

London, 1982

12. Knowles, J.H. (Ed.) Doing Better and Feeling Worse. Norton: New York, 1977

13. Fries, J.F. Aging, natural death, and the compression of morbidity. New England Journal of Medicine, 1980, 303, 130

14. Gruenberg, E.M. The failures of success. Millbank Memorial Quarterly, 1977, 55(1), 3-24

15. Miller, A.E. & Miller, M.A. Options for Health and Health Care: The Coming of Post-Clinical Medicine. Wiley: Toronto, 1981

16. McKeown, T. The Role of Medicine: Dream, Mirage, or Nemesis? Nuffield Provincial Hospitals Trust: London, 1976

17. White, N.F. In pursuit of health: the medical environment. In: The Health Conundrum: Explorations in Health Studies. OECA: Toronto, 1981

18. Fordyce, W. Behavioral Methods for Control of Chronic Pain and Illness. Mosby: St. Louis, 1976

19. Pomerleau, O.F. & Brady, J.F. (Eds.) Behavioral Medicine. Williams & Wilkins: Baltimore, 1979

20. Murphy, E.A. The model in medicine. In: Skepsis, Dogma, and Belief: Uses and Abuses in Medicine. Johns Hopkins: Baltimore, 1981

21. White, N.F. The evolution of morbidity: critical analysis of a model. (American Psychiatric Association Annual Meeting, Toronto, May, 1982.) (In Press)

22. Evans, J.R. Measurement and Management in Medicine and Health Services. Rockefeller Foundation: New York, 1981

23. Tugwell, P. & Bennett, K.J. The process of critical appraisal and its application to issues. In: D. Squires (ed.) Health in the 80's and 90's: Its Impact on Health Sciences Education. Ontario Council of Health: Toronto, 1982

24. Brody, H. The systems view of a man: implications for medicine, science and ethics. Perspectives in Biology and Science, 1973, 17, 71

25. Dawkins, R. The Selfish Gene. Oxford: London, 1976

26. Georgescu-Roegen, N. The Law of Entropy and the Economic Process. MIT: Cambridge, 1975

27. Laszlo, E. A Systems View of the World. Braziller: New York, 1972

28. Kuhn, T.S. The essential tension: tradition and innovation in scientific research. In: T.S. Kuhn, The Essential Tension: Selected Studies in Scientific Tradition and Change. University of Chicago: Chicago, 1977

29. Berkman, L.F. Physical health and the social environment: a social epidemiological perspective. In: L. Eisenberg & A. Kleinman (eds.) The Relevance of Social Science for Medicine. Reidel: Boston, 1981

30. Brenner, M.H. Importance of the economy to the nation's health. In: L. Eisenberg & A. Kleinman (eds.) The Relevance of Social Science for Medicine. Reidel:

Boston, 1981

31. Kane, R.L. (Ed.) The Behavioral Sciences and Preventive Medicine. DHEW(NIH) 76-878, 1976

32. White, N.F. (Ed.) The Health Conundrum: Explorations in Health Studies. OECA: Toronto, 1981

33. White, N.F. The humanities and health studies as partners: a modest proposal. (National Symposium on the Humanities, Vancouver, February, 1983) (Proceedings in press)