EXPERIENTIA

Volume 39/No. 10 Pages 1057–1180 October 15, 1983

Reviews

Occupational stress: understanding, recognition and prevention*

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Summary. Occupational stress occurs in the working environment where the stressors may be physical, chemical, biologic or psychosocial in nature. This review especially emphasizes the most novel and probably most prevalant type of work-related factors and response to them: psychologic stress. A brief historical introduction concerning the development of the (biologic) stress concept underlines the duality of stressors (i.e., extremely unpleasant and pleasant events, too much work and work stagnation) equally cause stress. A section on 'Recognition and manifestation' emphasizes the need for understanding the origins and nature of occupational stress before considering its manifestations (e.g., nonspecific behavioral changes and specific hormone level measurements). Under 'Prevention and treatment' reduction or avoidance of psychosocial stressors coupled with minimizing predisposing and promoting protective intervening variables are discussed. Thus, although occupational stress might be a major complication at the workplace, understanding this stress could lead to its partial or complete prevention.

The first short description of the biologic stress syndrome, published in 1936[35], introduced a new physiologic and pathophysiologic meaning for the term stress which until that time had been used only to denote physical stress and tension[35,36]. Most of the first stressors, agents that cause stress, were also physical entities (e.g., cold, heat, toxic chemicals). It was probably difficult to envisage at that time that subtle psychologic alterations and social imperfections, either in small, occupational or family setting, or at large in society, could also result in a similar stereotyped response in the body. Stress indeed is the nonspecific response of the body to any demand made upon it[39]. Occupational stress may be defined as stress occurring in the working environment, where the stressors may be physical, chemical, biologic or social in character.

The importance of understanding the stress concept lies in the fact that it is a complex syndrome elicited by diverse factors (fig. 1). This statement is often confounded by recurring discussions that Cannon was the first to describe the role of catecholamines and the adrenal medulla in 'fight or flight' reactions[8], but Selye was the first to recognize the importance of the steroid hormones, corticoids from the adrenal cortex. Cannon indeed has to his credit the elucidation of the importance of catecholamines in emergency reactions[8,27]. He, however, never accepted the contribution of other hormones. It was Selye who integrated new knowledge about the importance of adrenaline and noradrenaline with the crucial role of corticoids, documented in experimental animals and described the complex reaction sequence called 'General Adaptation Syndrome (GAS)'[35,36].

The historical turning point is that before the GAS every agent was thought to elicite only a specific reaction, while the stress reaction showed that agents greatly different in composition and intensity of action can produce a seemingly identical response which structurally consists of the 'triad of stress': enlargement of the adrenal glands, ulcers in the gastrointestinal tract and atrophy of the thymus and lymph nodes[35,36]. The scientific literature before 1936 (unfortunately, often even after that year) is hampered by descriptions and attempts to elucidate 'specific' ulcers or 'sudden involutions of the thymus' produced by one agent ... It is amazing that investigators did not think, despite the common, almost identical appearance of these lesions, about common elements and pathogenetic mechanisms which activate the (hypothalamic) pituitary-adrenocortical axis, resulting in hypersecretion of ACTH and corticoids, accompanied

* This review was originally intended to honor Hans Selye on the occasion of his 75th birthday. We were deeply saddened by the news of Professor Selye's death on October 18, 1982, and now this article is dedicated to his memory.

by a short elevation of plasma levels in catecholamines[35,36]. Furthermore, numerous functional, biochemical links have been discovered between adrenal medulla and cortex, i.e., the synthesis of catecholamines as influenced by corticoids and ACTH[3].

Implications of occupational stress

The implications of these findings for the better understanding of environmental and occupational stress were well illustrated by Levi[27] (fig. 2). It can be seen (fig. 2) that either positive, pleasant, or negative, unpleasant factors and events can elicit the stress response. It is always the same syndrome, since even though our brain might, our adrenal cortex cannot differentiate between a demanding boss and excitation over a kiss. Therefore, irrespective of the stressors, always the same ACTH, always the same glucocorticoids are secreted. Recently, an attempt has been made to label these two responses differently; distress, for the bad, 'adverse' effects, and eustress, for the pleasant, euphoric reactions[38]. This dichotomous distribution of stressors applies to occupational stress as well. Out of 9 major work-related psychologic stressors recently summarized, 7 have clear bivalent connotations[33]:

1. Work overload or work stagnation. 2. Extreme ambiguity or rigidity in work tasks. 3. Extreme role conflict or little conflict. 4. Extreme amount of responsibility or little responsibility. 5. Cut-throat and negative competition or no competition. 6. Constant change or routine stability. 7. Ongoing contact with 'stress carriers' (e.g., anxious people, indecisive individuals) or social isolation.

This 'U-shaped' intensity of stressors is not based only on Selye's theory and animal experiments showing that both overstimulation and understimulation are sources of stress and diseases[39]. These distributions have now been confirmed by objective measurements and interviews with workers describing their perception of stress[47].

Furthermore, it is also important to note that according to figure 1, every stressor, in addition to its nonspecific action, also has a specific effect (e.g., bacteria cause inflammation, insulin lowers blood sugar, noise affects the hearing apparatus). In addition, all these agents also increase catecholamine and corticoid secretion - hence, causing stress. Thus, when dealing with occupational stress, it is crucial to analyze every factor for its specific action (e.g., specific acute or chronic toxic effect, carcinogenic potential) before or in addition to considering it a stressor. Nothing can be only a stressor, but everything will have a stressor effect as well.

In this review mostly psychologic stressors are discussed although numerous physical (e.g., noise, temperature excesses) and chemical (e.g., toxic compounds without apparent immediate acute or chronic toxicity) stressors are also recognized in occupational setting. The emphasis of psychologic and social factors, however, does not originate from their novelty but from their high contemporary prevalence. In recent surveys participants indicate that 'about two-thirds of work stresses stem from interpersonal problems. Another third report stresses that arise from time-pressures'[13]. Psychologic stressors, partially because of our poor understanding of factors and processes involved, are difficult to characterize and, hence, to prevent, while physical and chemical stressors are usually easily measured and contained or eliminated. Furthermore, the ill-effects of exposure to noxious physical-chemical agents can be markedly enhanced, aggravated by psychologic stressors[23]. Thus, it is indeed appropriate to consider mostly psychologic stressors which historically are the most recent stress-causing agents in occupational settings.

In a historical perspective, one has to underline that work-related psychologic factors - although not labeled as stressors have been implicated in the causation of certain diseases since the late 1940's and early 1950's. The epidemiologist Halliday, in his book 'Psychosocial Medicine: a Study of the Sick Society'[19] also discussed fitness for jobs and concluded that

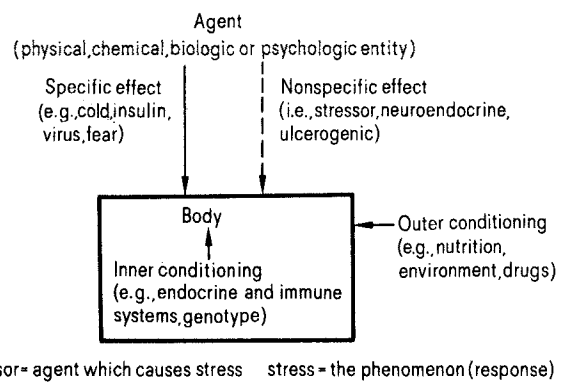

Figure 1. Specific and nonspecific (stressor) effect of various agents on the body according to Selye. (Reprinted from Szabo[44]).

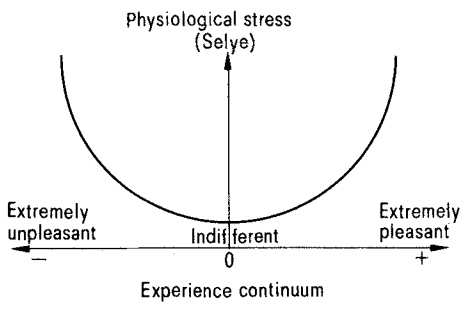

Figure 2. The relation between physiologic stress as defined by Selye and pleasant, indifferent, and unpleasant experiences of various environmental stimuli, e.g., 'life change'. Note that the physiologic stress level is lowest during indifference but never goes down to zero. (Reprinted from Levi[27]).

increasing work-related insecurity, income and status in society led to emotional tensions and diseases like hypertension and coronary heart disease (CHD). The clinical studies of Wolff and Wolf, linking social changes, stress and diseases are too well known to be analyzed here[48,50]. One of Wolff's associates, Hinkle, specifically studied workers and their attitudes towards work (e.g., 1300 telephone operators over 20 years). He concluded that healthy persons found their work satisfying and well liked in contrast to those who described their job as boring and confining reported many illnesses over the 20 year period[21]. In the now classic Life Change Events scale, constructed by another of Wolff's former coworkers Holmes and Parke[22], the work-related psychologic problems were listed among the moderate to severe stressors, equal or close to marital problems, major personal injury or illness, sexual difficulties and death of a close friend. These and other early studies concerning occupational stress are exhaustively summarized and discussed in monographs published in the early and middle 1970's[20,22,28,40,46,48], hence in this review, emphasis is given to the literature from the last 10 years.

A good part of the present day interest in occupational stress has its roots in the recognition that not only 'classic' psychosomatic diseases like hypertension, gastroduodenal ulcers and certain forms of asthma[31,33,44,48], but susceptibility to a variety of infectious diseases like influenza and other diseases (e.g., psychiatric disorders, heart and endocrine disturbances, cancer) are also influenced by stress[33]. The other points of interest are probably the public awareness and workers' interest in the problems relating to occupational stress and job satisfaction[6,14,49], as well as the willingness of most of the corporations to organize sessions or stimulate workers to attend courses to better understand, prevent and/or cope with work-related stress[5,33].

In a modern industrial society, practically no occupation is immune to a certain degree of stress. Some jobs, like air traffic controllers and hospital nurses, received extensive news coverage and public attention because of recent strikes and because of alleged excessive occupational stress and stress-related disorders[15,17,24]. However, doubts have arisen whether the stress is really unusual in quantity and/or quality and whether all segments of these 2 occupations are at equally high risks[17,42]. It is, nevertheless, probably worth considering certain occupations more stressful than others. This list of nonmilitary occupations according to Selye[40] includes air travel[25,32], air traffic control[17,24], automobile driving[41], executive work[2,45], medicine, dentistry and nursing[7,15,29,30,34,40,42], law and police work, telephone and telegraph industry and jobs involving shift work[24,28,40]. However, students, secretaries and numerous other types of workers were also analyzed for stress factors in their performance and health[40,51]. In all these occupations, psychologic stress was the major component, though an additive or even potentiating adverse effect was produced by physical-chemical stressors (e.g., temperature excesses and noise)[26,51]. Taking, thus, into consideration the ubiquitous occurrence of occupational stress, it is all the more important to recognize and prevent this byproduct of modern work.

Recognition and manifestation

Recognizing occupational stress may be based on the understanding of its origin and nature and on its manifestations. In this section the manifestations of stress and the principles of recognition will be discussed.

The morphologic triad of the stress syndrome, described on the basis of severe stress in animal experiments, has been mentioned earlier. It consists of adrenal enlargement, gastroduodenal ulcers and lym-

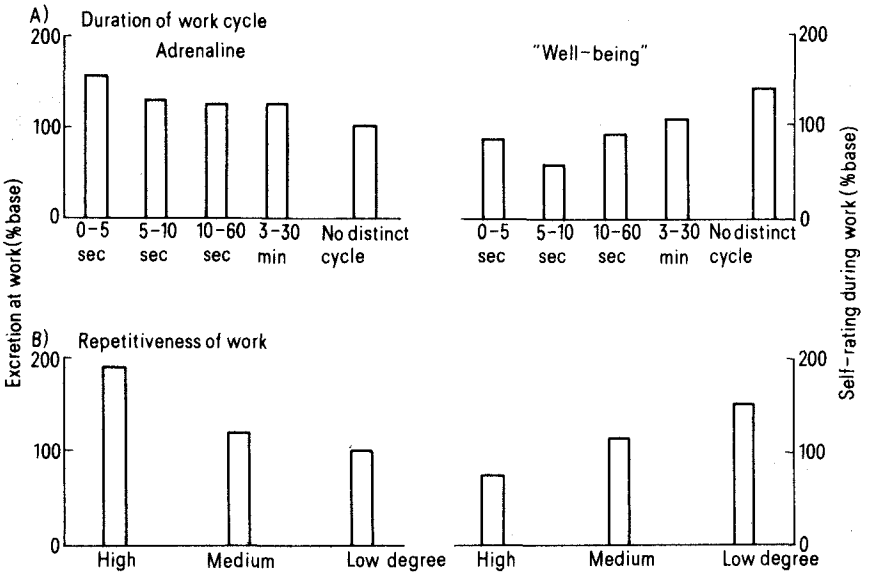

Figure 3. *A* Increase in excretion over resting levels of adrenaline in the urine of men exposed to differing lengths of work cycles is compared with their assessed feeling of well-being. Although not susceptible to statistical analysis, the data show a strong consistency of pattern and trend. The longer cycles are perceived as more desirable and accompanied by less adrenaline excretion. *B* The extent to which the work was repetitious also shows a good correlation with the biochemical measure. (Reprinted from Henry et al.[20]).

pho-thymic atrophy[35,36]. However, this basic historic recognition has multiple implications even today. Certain of these manifestations, like stress ulcers, may occur not only in severely ill patients but also under relatively mild but persistent forms of stress[31,44]. Furthermore, manifestations of stress may be recognized not only by structural alterations (marked morphologic changes may not even be present), but also or only by functional aberrations like behavioral changes[27,48], impaired response to drugs and to immunologic stimuli[37,43,44].

Based on the notion that the stress response is basically a neuroendocrine adaptation, involving especially the hypothalamo-pituitary-adrenal axis and the sympathetic nervous system[3,8,16,35,36,39] it is natural to measure hormonal changes as an objective index of stress. Historically, the list of these, relatively easy to measure endogenous chemicals include plasma and urinary levels of catecholamines (e.g., adrenaline and noradrenaline) and of glucocorticoids like cortisol, cortisone, 17-hydroxycorticosteroids (17-OHCS), less often androgens or estrogens. It is important to know what to measure under what circumstances, e.g., catecholamine output is rapidly elevated and subsided during stress, while blood and urinary concentrations of corticoids are high for a prolonged period of time. These parameters have often been applied to recognize and measure occupational stress. For example, when urinary excretion of adrenaline was measured in men as a function of length of work cycle and repetitiveness of work, high urinary levels of adrenaline were associated with short work cycle (e.g., 0–5 sec or 5–10 sec) and high repetitiveness of work; intermediate levels with work cycles of 10–60 sec or 3–30 min, or medium repetitiveness of work; and low concentrations with no distinct cycle or low degree of repetitiveness of work (fig. 3)[20]. These urinary levels of adrenaline were inversely related to 'well being' on a self-rating scale (fig. 3) and they represented an objective indication of stress due to short work cycles and high repetitiveness of work. Similar positive correlation was found between urinary output of noradrenaline and high, medium or low restrictions of work posture and control of work pace (machine paced vs self paced) as well as 'irritation' as an indicator of stress and expressed on a self-rating scale (fig. 4)[20]. This latter example is also a good illustration of combining physical (i.e., restriction of work posture) and psychologic stress (e.g., control of work pace and irritation over it). They also prove that the old and new animal experiments using restraint as stressors have a good human counterpart.

Urinary excretion of 17-OHCS was measured in persons classified as type A and type B[20,48]. The latter group exhibited a significantly higher response to ACTH than type A personalities (fig. 5)[20]. Based on serum or urinary noradrenaline change, type A persons (e.g., executive supervisor of a job under pressure of a deadline) responded significantly more than type B workers (e.g., municipal accountants working without time pressure) (fig. 5)[20]. These data also illustrate that the psychologic or psychiatric classification of people into type A or type B persons[20,48] may have some biochemical and physiologic background.

Several other hormones, neurotransmitters and their metabolites have been measured to recognize and quantitate stress response. In addition, other biochemical parameters from blood (e.g., cell counts, sedimentation rate, cholesterol, free fatty acids), blood pressure and ECG changes, alterations in respiration, and a large number of 'stress tests' have also been used to document occupational stress[40]. However, no clinical test or biochemical index is equivalent to the early, though relatively nonspecific indicators of stress in employees (e.g., feeling uptight and 'uneasy', change in appetite resulting in loss of body weight or overeating, certain skin reactions, alterations in mood and behavior). These changes in the absence of specific disease or other objective reasons may be taken as manifestations of stress and they call for rapid in-

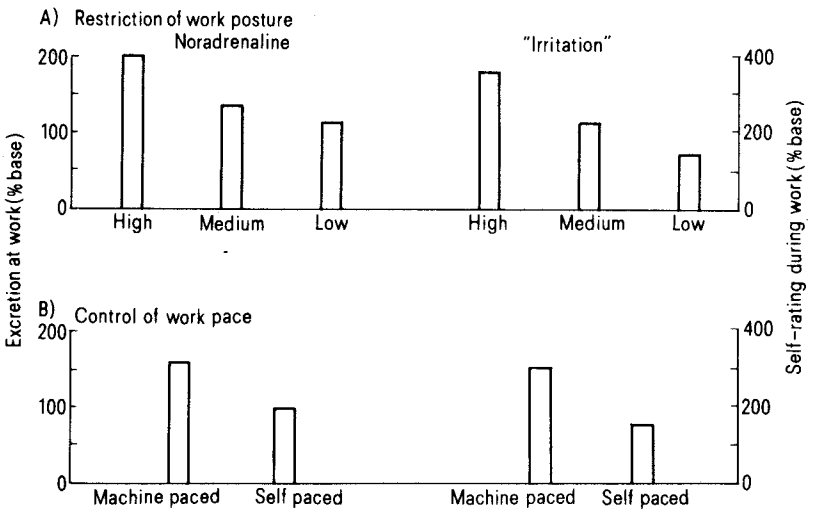

Figure 4. *A* Excretion of resting noradrenaline in urine of men who experience varying degrees of having to maintain the same posture throughout the working day. The excretion for 3 different degrees of restraint is matched against self-estimates of irritation at these restraints. *B* The procedure is the same, but the independent variable is the extent to which the work was machine-paced vs self-paced. (Reprinted from Henry et al.[20]).

tervention, treatment and prevention, possibly reorganization at the work place.

Prevention and treatment

Before analyzing possible means of preventing occupational stress it is important to realize that 'stress is not necessarily bad' and certain amounts of stress cannot be avoided in modern life[39]. The quantity and quality of job pressures must be achieved for optimal more-than-average performance[18]. 'One must understand that power, influence and authority exist in any organization'[13]. Concerning work stress 'fight or flight is more appropriate to the lower animals, man is more able to fight, fight or take things in stride'[13]. Possible means of prevention and treatment, however, must be sought in order not to reach the stage of 'professional burn-out syndrome'[1] which is equivalent to the last stage in the tri-phasic stress response (i.e., alarm reaction, stage of resistance and exhaustion)[39].

Many schematic pathways linking stressors with diseases and listing possible sites for intervention have been proposed. One of the simplest yet most comprehensive is the pathogenesis proposed by Kagan and Levi[27] (fig. 6). It emphasizes the actual removal of stressors, the understanding of mechanisms (i.e., stress response), the intervening variables and precursors of diseases (fig. 6). The general approach suggested by these authors consists of reducing, eliminating or avoiding psychosocial stressors and minimizing predisposing, promoting protective intervening variables (e.g., habituation, adaptation, substitution, learning, conditioning, belonging to a group, available acceptable substitute activities, availability of someone to talk to about own troubles, and education)[27].

Concerning the specifics of occupational stress, Kagan and Levi promote 9 detailed means of intervention[27]:

1. Detailed multidisciplinary ergonomic research aimed at describing all existing job types as well as those planned in the near future.
2. Full access to psychotechnical institutes offering a proper selection of aptitude tests.
3. Optimal utilization of the information mentioned in the two above paragraphs for vocational guidance, including wide dissemination of informative publications as well as broadcasting of specially designed radio and television programmes.
4. Better vocational guidance and advice through the activities of school welfare officers and school psychologists (as things stand, many young people devote more care to the choice of a new car than to the choice of a job).
5. Systematic multidisciplinary studies of man at work with continuous remodelling of the various jobs in order to suit man's abilities and needs, starting as relatively small-scale psychosocial field studies and ending as a reshaping of working life on a nationwide or even international basis.
6. In accordance with the above paragraph, special attention should be devoted to the proper selection and design of jobs for the mentally, physically, and socially handicapped.
7. Better personnel management and comprehensive staff welfare programmes at all levels in working life:
   a) optimal rate of development, avoiding too few, too many and too radical changes;
   b) security at work (also emotionally, not only physically and economically);
   c) optimal working pace (not necessarily maximal);
   d) meaningfulness of tasks and assignments in order to avoid alienation;

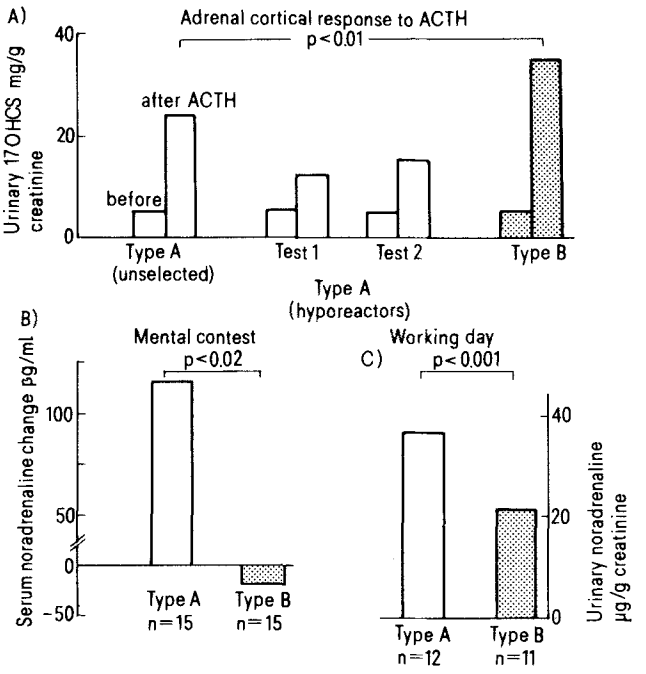

Figure 5. A composite of 3 experiments contrasting the neuroendocrine responses of subjects with personalities defined as type A with those defined as type B. *A* A fixed dose of ACTH induced significantly more excretion of 17-OHCS in urine of the type B than the type A persons ($p < 0.01$). Of the total of 18 type A persons, 6 were hyporeactors who hardly responded at all. Similar differences are found in dominant monkeys and mice. *B* When type A persons were pitted against type B persons in a mental contest, their serum noradrenaline level rose while that of type B did not change. *C* When the excretion of noradrenaline in urine of type A persons was contrasted with that of type B during the working day, it was significantly higher. Taken together, these studies suggest that the type A and the type B persons differ in the responsivity of their sympathetic adrenal-medullary and pituitary-adrenocortical systems in the same way that dominants differ from subordinates (reprinted from Henry et al.[20]).

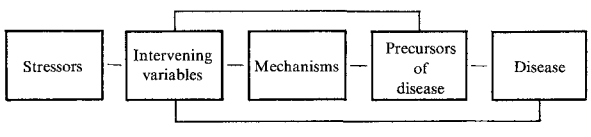

Figure 6. Pathogenesis of stress related diseases. (Reprinted from Levi[27]).

e) optimal information and contact between peers, and between superiors and subordinates, creating optimal group 'belongingness';
f) harmony between and clear definition of responsibility and powers;
g) harmony between ambition and ability (good self-knowledge);
h) optimal opportunities for personal development and utilization of potential abilities;
i) optimal self-esteem for the individual and the group;
j) optimal job design with regard to, e.g. shift-work and mode of remuneration;
k) elimination of discrimination between the sexes, races and age-groups with regard to payment, assignments and conditions of work;
l) increased influence and power for individual employee, employee committees, and trade-union movement in the design of work processes, work environment and conditions of work;
m) adaptation of the value system of working life to life in general, with proper consideration of the balance between economical and other value systems (economic values must sometimes be sacrificed in favor of other values like health, welfare, etc.).

8. Pre-employment and periodical medical examinations should be performed on all employees and comprise psychological and social aspects in addition to medical ones. High-risk groups, i.e. employees who are constitutionally vulnerable or especially exposed to stressors should be kept under frequent medical supervision.
9. Integration of all aspects of job design, personnel administration and staff welfare into comprehensive programmes of primary and secondary prevention. This will form the basis for the next industrial revolution. This is a challenge for biological and behavioural scientists.

Since occupational stress is 'multifaceted, multidimensional syndrome', many possible interventions exist both at and outside of the work place[12]. Some of these techniques are nonspecific like meditation, relaxation response which can be simplified to sitting down in a quiet place and repeating semiloud a single word[4,9,33] or participating in social events or sport activities during breaks and/or outside work[12]. Other more specific methods are designed for certain professions (e.g., executives, physicians, nurses)[5,10,11,29,40,42]. Specialized seminars like the Menninger Seminars for Industrial Mental Health have been in operation for several years[5] and their number is constantly growing. If these preventions fail, the imminent disease may still be prevented or treated with specific interventions aimed at disease producing mechanisms (e.g., mental processes, endocrine, especially adrenal functions, immunoreactions and psychosocial processes)[27].

The complex means of prevention and treatment may still be surpassed or at least preceeded by simple steps like listening to others who experience work related stress and developing 'respect for one's coworkers, even when liking others has become difficult if not impossible'[51]. Accepting the constant changes and opportunities for learning in life and building a healthy personal philosophy of life may also be crucial factors. The 'ultimate aim' is for one to 'express himself as fully as possible, according to his own lights' and to realize that it is not the stressors 'but our reactions' to them which matter. The above can best be summarized in the following two lines from Selye's book[39]:

'Fight always for the highest attainable aim
But never put up resistance in vain.'

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Reagents for photoaffinity labeling. I. Photobinding efficiency of aryl azido-, diazocyclopentadienyl- and ethyl diazomalonyl-derivatives of 9-aminoacridine

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Summary. A method for the comparison of photoaffinity labeling probes has been developed and tested with model reagents containing 5 different photoprobes attached to 9-acridinylamino groups through hexamethylenoxy or hexamethylenamino linkers. The fluorescence properties of the acridine part of the reagents were employed for detection of the labels. The merits and disadvantages of the different photoprobes are discussed. The photoreaction of the reagents with proteins (bovine serum albumin and histones), RNA (ribosomal), and DNA (calf thymus) were studied in order to compare the efficiency and suitability of aryl azido and diazo photoprobes. By using Pyrex-filtered light ($\lambda > 300$ nm), it was observed that the reagents derived from 4-azidobenzoyl- (**a**), 4-azido-2-nitrophenyl- (**b**), or 2-diazopentadienylcarbonyl- (**c**) are the most efficient, labeling bovine serum albumin in yields of 22%, 9% and 9%, respectively, with relative rates of 0.25:0.06:1. The acridines containing photoprobes **a**, **b** and **c** were shown to function as photoaffinity labeling reagents of the histones in chromatin.

Photoaffinity labeling has by now gained an important position as one of the most versatile tools for the study of active sites and macromolecular interaction in molecular biochemistry[3–6]. Previously aryl azido and diazo compounds were the preferred photoprobes due to their high quantum yields. Furthermore, their photolysis was assumed to lead to nitrenes and carbenes, which could result in very rapid reactions, in