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**EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON**

Commanding Officer CAPT M.A. Howard, USN
Scientific Director James W. Daniel
Editor Larry E. Shaffer

February 1985
Volume 39
Number 2

**BEHAVIORAL
SCIENCES**

Cognition-Motivation Interaction:

German Research on Achievement Motivation,
Volition, and Action Control Richard E. Snow 33

Heinz Heckhausen and Julius Kuhl of the Max Planck Institute for Psychological Research are leaders in developing an information processing theory of motivation, volition, and action.

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Preliminary results from Sweden suggest that high-level microwave exposure may affect certain proteins in the nervous systems of radar maintenance technicians.

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One of the major themes of the conference concerned calcium ions--their role in regulating cellular function, their transport into and out of cells, their binding to various sites, and their effect on electrical properties of membranes and channels.

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BEHAVIORAL SCIENCES

COGNITION-MOTIVATION INTERACTION: GERMAN RESEARCH ON ACHIEVEMENT MOTIVATION, VOLITION, AND ACTION CONTROL

by Richard E. Snow. Dr. Snow is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1985 from Stanford University, where he is Professor of Education and Psychology.

To understand human performance in any complex task environment, one must understand not only the perceptual-motor and cognitive processes involved in such performance but also the conative and affective processes that interact with these processes. A previous article (ESN 38-7:349-352 [1984]) argued that most of US cognitive psychology was still largely ignoring such interactions, though it was noted that there have been some recent signs of change. It then identified examples in recent Belgian research that might promote further change in US thinking. The present article continues this theme by summarizing some theoretical advances coming from the work of Heinz Heckhausen, Julius Kuhl, and their collaborators in the new Max Planck Institute for Psychological Research, Munich, West Germany. There is much other German research on this topic today as well. But Heckhausen and Kuhl lead the way; they combine old ideas in German psychology with very new ideas, and suggest that American theory is shallow in comparison.

The Heckhausen-Kuhl view is that US cognitive psychology is defined too narrowly and at the same time too broadly. It is too narrow because it concerns itself exclusively with cognitive information processing, regarding motivational and volitional phenomena mainly as derivatives of basic cognitive functions (see, e.g., Norman, 1980, 1982; Mandler, 1983). It is too broad because, given the above narrowness, it then proceeds to generalize across all manner of situations and conditions that differ drastically in their motivational and volitional implications (see, e.g., Anderson, 1983; see also the British work of Hamilton, 1983). The problem derives in part from over-inclusive use of the term "cognitive," which has come, in the last 20 years or so, to be identified with just about any mental phenomenon. But

one can do information processing analyses of motivation, volition, and the control of action to show that the processes involved in such phenomena differ functionally from strictly cognitive processes. Thus a theory of motivation, volition, and action control can be an information processing theory, but it will not be simply a cognitive information processing theory.

Heckhausen and Kuhl restrict the term "cognition" to those processes that mediate acquisition and representation of declarative and procedural knowledge about the world--that have a representative relation to the world of objects and facts. These are to be distinguished from "emotional" processes that evaluate the personal significance of those objects and facts and "motivational" processes that direct and control actions in the world--that relate to goal states of persons in their attempt to produce desired changes in the environment. (I would prefer the terms "affective" and "conative" instead of "emotional" and "motivational," respectively, but terminological preferences need not be belabored here.)

The taxonomy of Figure 1 (from Kuhl, in press a) results from these distinctions. Within each of these three domains, an intensity continuum further distinguishes various mental states. Cognitive representations differ in degree of certainty. Emotional states differ in degree of acceptance or rejection. Motivational states differ in degree of commitment. It is this last domain, with its commitment continuum, that particularly deserves theoretical attention because it has been given the shortest shrift in modern cognitive theory.

What is commitment? What processes transform wishes into wants, wants into intentions, and intentions into actions? What keeps some wishes, wants, and intentions from progressing to actions? What regulates the temporal flow of actions and their effects on subsequent actions? These are the sorts of questions here addressed (see Heckhausen and Kuhl, in press).

The Basic Theoretical Framework

Figure 2 elaborates the continuum model with which Heckhausen and Kuhl are now working. It derives from the extensive prior research done by Heckhausen on the Expectancy x Value Theory of achievement motivation and by Kuhl on a theory of volition and action control; all this background cannot be detailed here (see Heckhausen, 1974, 1977, 1980, 1981; Kuhl, 1982, in press a, b, c, d). Primary attention focuses on approach

tendencies related to positively valued goals; wishes, wants, and intentions to avoid negative or aversive events involve other complications and are left aside for the present. In the model, there are four categories of motivational variables operating along the commitment continuum from wishes to actions: values, expectancies, relevance, and activation. There are also three goal levels arranged in ascending hierarchical order: actions, outcomes, and consequences. In Figure 2, only one wish-action pathway is shown, but it is important to recognize that the motivational variables may be different and

may operate in different ways when different levels of goal or end state are focused upon.

A wish is essentially the undifferentiated value attached to a goal. At any given goal level, the values are the valences or incentives related to an anticipated end state. Expectancies derive from the potency of the goal--the unconditional subjective probability of its attainment. Potency becomes expectancy (E) when the probability of attaining the goal becomes conditioned on a certain action. Valence (V) and potency (P) are terms used in honor of Lewin (1935), the German psychologist who

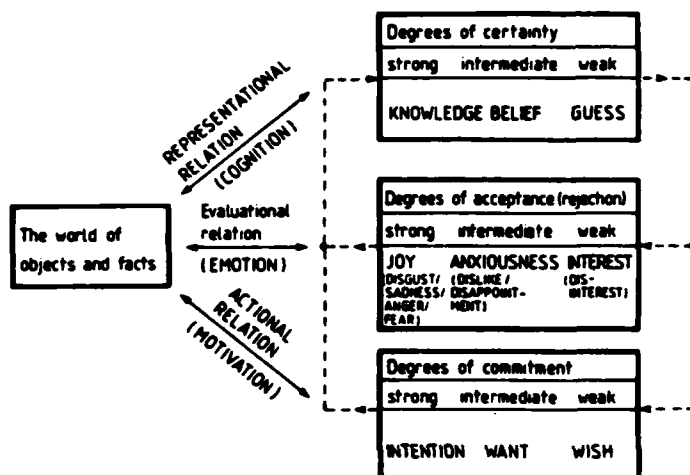


Figure 1. A taxonomy of cognitive, emotional, and motivational states (after Kuhl, in press a).

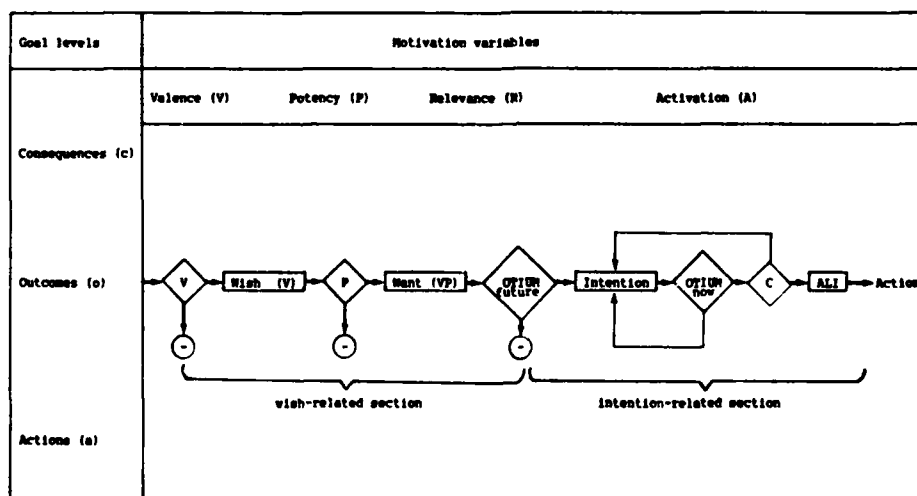


Figure 2. Flowchart of the wish-action pathway with classes of motivational variables and goal levels (after Heckhausen and Kuhl, in press).

first defined them. Stemming from Lewin, but also from Atkinson and Feather (1966) and especially Heckhausen (1977), there is now substantial theory dealing with the value-expectancy computation that predicts what the preferred goal will be once an individual is committed to action. Until this new work of Heckhausen and Kuhl, however, value-expectancy theory has been silent about the wish-action pathway; the relations among goal levels have also not previously been clarified.

One kind of expectancy variable that is important in considering relations among goal levels is the instrumentality (I) of an action outcome for desired or feared consequences. The instrumentality of an outcome is the probability of the occurrence of some consequence given that outcome. At the action level, the end states are the actions themselves; motivation derives from interest, enjoyment, or excitement in performing the act in and of itself. But actions lead to outcomes (the second level) that also have value in themselves, and outcomes have consequences (the third level) also with their own values. Instrumentality connects action, outcome, and consequence.

A wish becomes a want when it becomes endowed with sufficient expectancy and instrumentality (i.e., when it reaches a critical threshold of potency). It transits from a plane of fantasy to a plane of reality when subjective probabilities for attaining the implied goal exceed a critical level. If a want refers to a higher-order goal level (e.g., a particular consequence of an action outcome), then a complex of other motivational processes are implied; processes at higher levels presuppose or include the processes at lower levels. Also, when lower-level end states are focused upon for their own sake, the process can also incorporate valences from higher-order levels. One can speak of "borrowed" valences from either higher or lower orders, although normally lower-level goals receive their valences from higher-level goals. So, for example, the act of studying receives valence from the goal of passing the course examination, which is in turn determined by its instrumentality with respect to the goal of admission to a higher level of education.

A want must be relevant for the individual in addition to being realistic; variables in the relevance category determine the transformation of wants into intentions. According to the model, the relevance check includes concern for practicality and appropriateness to a

particular setting or situation. This check is based on at least five criteria: opportunity, time, importance, urgency, and means (hence the acronym OTIUM in Figure 2). To change a want into an intention requires passing an OTIUM-future check--will conditions favor the intended action in the future? For the intention then to be transformed into an action, a second, OTIUM-now check must also be passed--are conditions favorable at this particular moment? A final checkpoint is self-control (C) to determine if the action program is complete and can be maintained against competing action tendencies. If these checks are positive, action is initiated by an action-launching impulse (ALI).

Preliminary Evidence

Various implications of the above model seem substantiated by the evidence so far in hand. Wishes that cannot pass the potency check, and also wants that cannot pass the relevance check, remain in an endless loop or spin, but they direct attention; they condition the individual to be vigilant for information that might be useful in clearing criteria along the wish-intention part of the pathway, and so appear to determine how much thinking time is devoted to particular concerns. There is evidence from thought-sampling studies that people spend most of their thinking time on goals that have high incentive values and on threatened or unexpected difficulties and special challenges with respect to valued goals. They also frequently report thinking suggestive of the components of the OTIUM check. With the extensive interview data so far collected in Munich, also, the model is seen to provide a useful structure for description across cases. It thus has at least heuristic value for further research.

The demarcation between wants and intentions also seems justified empirically. In the Heckhausen-Kuhl theory, this critical point distinguishes the *motivational* processes involved in elaborating and integrating values and expectancies and the *volitional* processes that carry the intention to eventual enactment in due time and at the appropriate occasion. The theory thus makes the motivation-volition distinction clear for the first time, and also clarifies some long-standing puzzles in the empirical evidence.

One such puzzle is the conflict between the evidence that tasks of intermediate difficulty for an individual evoke maximal effort, and thus produce better performance, and the evidence

that assigning tasks of higher than intermediate difficulty for the individual results in higher aspiration and effort, and thus better performance. The puzzle is removed by recognizing that the expectancy theory leading to the first body of evidence concerns the individual's effort and performance on *chosen* tasks of different difficulty--a motivational process--whereas the goal-oriented theory leading to the second body of evidence concerns the individual's effort and performance on *assigned* tasks of different difficulty--a volitional process. Increase in strength of volition in proportion to encountered increase in task difficulty was recognized as a separate, volitional as opposed to motivational principle as long ago as Ach (1910), but the distinction was rejected by Lewin and thus ignored by US psychology since (see Kuhl, in press b).

Two other examples come from studies of response latencies for different stages of actions and from studies of imagining behavioral scripts. Response latencies for the predecisional, motivational stages and the postdecisional, volitional stages clearly follow different principles; many studies confound these latencies. Imagining the performance of certain actions influences volitional aspects of the intention-action path, but does not influence the perceived value, i.e., the motivational, aspects of actions, outcomes, or consequences.

Elaboration of Self-Regulatory Processes

The intention-action phase of the pathway can be further elaborated, because it is clear that the self-regulatory processes involved in this phase are multiple and vary considerably over persons and situations. At least six types of such control processes can be distinguished (see Heckhausen and Kuhl, in press; Kuhl, in press c, d).

When a current intention fails the OTIUM-now check, it is transferred to long-term memory, where it may remain a current concern to be activated whenever a new situation in which the OTIUM-now criteria are met. A current intention that meets the OTIUM-now criteria is considered an activated intention--activation elicits control processes to facilitate the production of action. One control process involves priority decisions when more than one competing intention is activated; multiple intentions must either be combined or sequenced. Another control process is involved in intentionally changing the situation so that the relevance of a

nondominant intention is increased to meet OTIUM-now criteria.

Another class of control processes allows persistence or purposeful striving toward an intended goal once it has been chosen for action by shielding it from competing intentions. This may be accomplished, for example, by increasing the incentive value of the intended goal. Much of the evidence from research on cognitive dissonance can be reinterpreted in this action control framework as a facilitation of the continuance of a chosen course of action. Still another type, or perhaps level, of control processes comes from individuals' knowledge of their own self-regulation. They can choose among their own self-motivating strategies and thus make use of what might be called "metavolitions."

There are also control processes concerned with scrutinizing activated intentions for defective components. There may be fluctuations in a situation that cause a previously met OTIUM criterion to become unmet. There can also be shortcuts in the system whereby activation may have resulted even though prior criteria were not met. Intentions can be retrogressed to an earlier stage or held in working memory if imminent action on them is deemed undesirable.

Finally, if action results in failure and the intended goal is not reached, self-regulation processes come into play to abandon the intention, or postpone it, or revise it. The intention can also become degenerated--kept in working memory without attempt at improvement. The effects of a string of failures and of certain personality dispositions may be understood in terms of intention degeneration or self-regulatory failure. Working memory capacity spent on ruminating thoughts about past or present failures or nonattainable end states is called a "state orientation," whereas improvement or change of intentions to allow action to proceed is called an action orientation (see Kuhl, 1982). Measures of individual differences in state versus action orientation relate to measures of depression, suggesting that the passivity apparent in depressive persons may be attributable to state orientation--an inability to clear working memory of degenerated intentions that cannot be carried out. Some further evidence suggests that state orientation resulting from failure on previous tasks that produces performance deficits on a new task can be reversed by asking subjects to verbalize the problem-solving process. This may encourage subjects to avoid short cuts in processing task-related wants and may

also improve self-regulation to avoid the persisting intentions connected to previous failures.

Much evidence gathered using a variety of other approaches to the study of action control is summarized by Kuhl (in press c) to support the volitional and self-regulatory processes distinguished in his theory. The implication is that much other work--on achievement-oriented behavior, delay of gratification, and learned helplessness, for example--can be integrated into a comprehensive theory of action control. Most importantly, the theoretical and empirical work in this direction demonstrates clearly that what Kuhl calls the "motivation doctrine" must be rejected. According to Kuhl (in press d, p. 163) this doctrine assumes that: "If a person has the cognitive abilities and motor skills to perform a given behavior, a failure to perform it in a specific situation is indicative of a motivational deficit." Instead, the mediating role of volitional processes must now also be considered. Failure to perform may result from an inability to shield the task-oriented intention against competing action tendencies, such as thinking about the evaluative implications of past failures on other tasks. Persistence also comes to be viewed in volitional as well as motivational terms here. Persistence is not only a function of strength of motivation relative to motivation to switch to other activities; it is also a function of the ability to protect the task-oriented action tendency against competing intentions.

Extensions

The main job for Heckhausen and Kuhl now is to consolidate their combined theory of achievement motivation and volition, and to investigate its many further implications. The pursuit of improved, more analytic measurements is one aim. For this methodological purpose, but also for important substantive reasons, the project is investigating in more detail the connections between its work and advances in cognitive information processing psychology. There are many exciting prospects here for the future.

But there are also other extensions being pursued that should be noted. One line of work investigates the life-span development of achievement motivation and action control. Another considers the possibility of motive modification by instructional interventions.

Concern with one's own competence is a lifelong theme in all persons' interactions with their environments.

With development, however, come dramatic shifts in the meaning of situations for one's concept of self-competence. Unraveling the motivational and volitional aspects of these shifts is an intriguing problem. Heckhausen (1983) cites three examples from the developmental side of his program of research.

One example contrasts younger and older children's reactions to an experimenter offering help in performing a task versus taking over the performance of the task. Before about age 2½, children accept offered help readily--receiving help does not spoil the pleasure of pursuing the goal. But they become angry at having to give up the task to another--that is a threat to the originating self. After age 2½, children reject offered help, as it is a reflection on their self-concept of competence. But they accept another taking over the task as a parallel or turn-taking activity that does not reflect on their competence.

Another example comes from studies of students ranging through grades 3 through 12. In this period, the concepts of ability and effort and their relation to task achievement develop. In particular, students gain a compensatory causal schema in which it is realized that a lack of ability can be compensated by effort and persistence, at least to some extent, and that a lack of effort or persistence can be compensated by ability. But realization of the two sides of this schema comes at different points in development. Younger students perceive effort as the prime cause of achievement; they disregard ability at first and later infer ability from effort. Failures do not lead to the rather depressing inference that one lacks ability. Praise (from others, such as parents or teachers) encourages young students because it is seen as linked to effort. But reaction to praise (and blame) reverses at a later point in development. Students gradually learn that adults give praise and blame primarily as a function of effort in relation to ability. They come to infer from praise given to effortful success that the adult thinks them incompetent! They also infer from blame given to a relatively effortless failure that the adult thinks them competent. When students also have independent information about task difficulty, they can infer directly how an adult assesses their ability level. The most damaging inferences about one's own ability come from adult praise for success on easy tasks, or the lack of adult blame for failure on such tasks; both imply lack of ability. Blame for failure on a

difficult tasks, on the other hand, provides an ego boost because it implies that ability was equal to the task but only effort was insufficient.

A third example relates to the motivational traps common in middle adulthood, especially among highly achievement-motivated individuals. These connect to the Heckhausen-Kuhl distinction between the goal levels of outcome and consequence. Outcomes are seen by adults as depending on their own competence, whereas consequences are seen as also dependent on environmental circumstances. For adults, most of the motivating incentives attach to the consequences. Action control is geared to the instrumentality of outcomes for desired consequences. When this instrumentality breaks down, action control becomes useless, and hopelessness, resignation, bitterness, and disengagement can result.

In a course for corporate executives, aged 45 to 55, it was possible to distinguish three motive patterns. About 50 percent of the executives showed stronger power motivation than achievement motivation--that is, their action control was oriented more toward common social goals of work group or corporate productivity and morale rather than toward individualistic, self-interest goals. About 30 percent of the executives showed stronger achievement motivation than power motivation--that is, they were more oriented toward individually challenging tasks and competition with self or others against standards of individual excellence. About 20 percent were high on both motives. The sample could also be divided independently into two levels of success so far achieved in life; persons who had reached the highest level of promotion realistically to be attained, and persons who, while moderately successful, had not reached the highest probable level of promotion, and now would not do so because their age would increasingly work against them in corporate promotion policy.

Comparisons among these groups yielded some marked contrasts. Achievement-motivated executives who had not reached their highest probable promotion level were bitter about the contradiction they experienced in action control. While they remained effective, controlling action-outcome expectancies to excellent result, these excellent action outcomes no longer led to the valued consequences. They felt blocked, hopeless, and resigned to their fate, which reinforced the corporate decisions against further promotion. The power-motivated executives in this less than

maximally successful group, on the other hand, were less gloomy and resigned. As they saw an end to their rise to the top of this power structure, they compensated by pursuing leading positions in power structures outside the corporation, such as in political or social activities.

Among those reaching the highest promotion levels, the achievement-motivated executives faced a different sort of contradiction. Now, achievement-motivated incentives dropped out and power-motivated goals were required. This drastic change in occupational demand, for group-oriented leadership rather than individual achievement, produced problems of change in action control: their motivating incentives and self-evaluation in this domain were lost; they lacked self-efficacy in the new power-structure orientation and were inexperienced and clumsy in it; they had trouble inhibiting achievement-related actions or delegating them. The result was depression and conflict. Power-motivated executives, however, felt they had finally "made it"; they bloomed in their increased personal control, and devoted their abilities and time even more fully to effective leadership.

The small group of executives high in both motives had leadership difficulties too; they set overly high standards for their subordinates, were unpopular and failed to create the good morale that their equally power-oriented but less achievement-oriented peers were uniquely able to produce.

These examples show the importance of a developmental view of motivation and volition and underscore the need for longitudinal studies, tracing both forward and back from the school age subjects most typically studied in prior research. The development of achievement motivation, especially in young children, is a line toward which one part of Heckhausen's program has now turned (see, e.g., Heckhausen, 1981, 1982, 1983, 1984; Trudewind, 1982).

Motive modification is another new direction. For some decades there have been attempts to develop training programs that could alter and improve the achievement-motivational structure of performance in both school situations and in the work place. In contrast to the earlier work, however, Heckhausen and Krug (1982) and several other colleagues gear their training programs closely to their theory of achievement motivation; in particular, they focus on the individual determinants of self-evaluation and self-reinforcement and on individual as opposed to group reference norms.

Compared to success-oriented persons, individuals who are failure-oriented typically have unrealistic performance standards and attribute success and failure in ways that reflect unfavorable self-assessments of ability. They escape from achievement-oriented activities if possible, or choose tasks with difficulty levels far above or below their abilities. This self-defeating pattern keeps them from realizing their actual abilities or developing self-confidence. The training aims to interrupt this cycle by improving realistic goal setting and changing attribution patterns to be more self-reinforcing. The motivation as well as the behavior is presumably changed.

Results to date show at least partial success, and have opened up many further questions and complications for research. The training programs can show motivational improvements but these effects do not always transfer to improved performance outside the training itself. There can also be negative effects if enhanced motivation in training is not accompanied by change in the task structure of regular instruction for low-achieving students. Perhaps the most powerful factor in enhancing achievement motivation has been found to be individual as opposed to group norm referencing. Instructors who employ a longitudinal perspective within individual students tend to compare present performance of the individual with past performance for that individual, to assign next tasks of appropriate difficulty based on the individual's learning progress, and to give feedback as a function of the within-person comparison. Instructors who instead compare individuals with others in a group at any point in time (i.e., a more cross-sectional perspective) tend to assign the same tasks for all individuals, and to give feedback as a function of the between-person comparison. The individual norm referencing approach has produced marked improvements, particularly among initially lower achievement students. It appears, however, that more able students are perplexed and unhappy under individual referencing; they of course are the ones who benefit by cross-group comparisons. Also, it has been shown that instructors differ markedly in the degree to which they naturally use one or the other referencing system. Teacher training can promote more individual norm referencing but not with routine success.

Finally, it is clear that social norm referencing should not be eliminated entirely because it serves to measure relative task difficulty and to contribute to the development of realistic

self-concept. Thus the question becomes: What mix of individual and group norm referencing is optimal?

In short, the Heckhausen-Kuhl theory leads to new analyses of both educational and industrial organizations as developmental environments for the motivational and volitional sides of human performance. Watching the continuing evolution of this theory and research should be most rewarding for US psychologists.

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BIOLOGICAL SCIENCES

CHANGES IN CEREBROSPINAL FLUID PROTEINS FOUND IN RADAR WORKERS

by Thomas C. Rozzell. Dr. Rozzell is the Liaison Scientist for Biological Sciences in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until August 1985 from the Office of Naval Research, Arlington, Virginia, where he is Program Manager for Cellular Biosystems.

Preliminary results from Sweden suggest that high-level microwave exposure may affect certain proteins in the brains of radar maintenance technicians.

I recently visited the University of Göteborg, where I had extensive conversations with Dr. Hans-Arne Hansson of the faculty of medicine. Hansson described in some detail the changes that he and other members of the faculty, in the Department of Neurology, have observed in a number of radar workers and laboratory animals exposed to high-level microwaves. While these results are preliminary now, Hansson and his team have a number of replicates and are in a position to discuss the data. In this article, I will give details of these new findings, but stress again that they are preliminary.

As a physician, Hansson serves the military complex at Göteborg by providing medical care two mornings per week for enlisted persons and officers. Part of the group that he sees comes from the radar school. This is a school that trains radar operators and maintenance personnel. In a visit to the school, I observed the physical layout of the radar equipment, including antennas, generators, and operating consoles. I also discussed the current safety regulations with officials at the school.

Within the last 2 years, Hansson has seen about 11 radar maintenance technicians who were long-time (15 years or more) employees of the school. These men all had symptoms of central nervous system damage. Many were unable to perform the jobs properly and had a number of complaints that led Hansson to send them to the Department of Neurology for a more thorough examination, which included an analysis of the protein patterns in their cerebrospinal fluid (CSF). He decided to do this as a result of some observations that he had made in rabbits whose heads had been exposed to high levels of microwaves.

The analysis of the CSF of the radar workers showed the same changes in the protein patterns as was found repeatedly in the rabbits. In order that the reader might better understand the significance of these findings, I will discuss some details of the procedure.

CSF plays a role in maintaining stability in the central nervous system. It has a characteristic crystalloid and colloid composition. Changes in the composition of the CSF reflect changes in the metabolism of the brain, in the cerebrovascular state, and in the CSF hydrodynamics. Proper analysis of CSF can indicate pathologically degenerative brain diseases. The majority of the proteins normally present in CSF are derived from serum, and the protein content in CSF is about 1/200 of that in serum. This difference is maintained through the relative impermeability of the blood-brain barrier (BBB) to large macromolecules like proteins. Passage through the BBB seems to depend on both filtration and vascular transport.

A technique has been developed at the University of Göteborg to separate CSF proteins. It is essentially an affinity chromatography method that employs isoelectric focusing as an analytical electrophoretic system (Wikkelsø, 1982). In this method, the CSF-specific protein fraction is separated into approximately 30 protein bands by isoelectric focusing. It is possible to accurately identify prealbumin, microglobulin, and beta-trace proteins. If there are changes in the proteins--either qualitatively (i.e., there are new ones present or old ones missing) or quantitatively--they are readily seen by this technique. Since CSF has been studied for many years and taking it is relatively routine in a large number of diagnostic procedures in neurology, there is quite a bit known about the "normal" pattern of CSF proteins. The method is used as a complementary diagnostic tool in degenerative central nervous system disease.

When Hansson began studying rabbits, he exposed them for 1 hour at an average power level of 55 mW/cm, using 3.07-GHz microwaves pulsed at 300 Hz (the pulse width was 1.4 μ s). While the average power was 55 mW/cm, the peak power was approximately 1000 mW/cm. He reported that the specific absorption rate was measured in the rabbit brain and found to be 20 W/kg average. Exposures were to the right side of the head while the animal was restrained but not anesthetized. During this time, the brain temperature rose about 1°C.

When the CSFs of these rabbits were analyzed (blindly) by the neurochemist at the Department of Neurology, it was found that there were different patterns of proteins in the exposed animals than in the controls. These are not subtle differences requiring a lot of expertise to observe. They are very dramatic, with very different bands which I could clearly see with my untrained eye. Furthermore, upon microscopic examination of the brain on the exposed side of the head, it could be seen that there are morphological changes in the glial cells. Here again, these are very dramatic and not difficult to see. As evidence of this, Hansson let me look at some slides--and without knowing what I was observing, I could readily see and describe the difference between sets of brain tissue that (I later learned) came from different sides of the head of an exposed animal and tissue that came from the brain of an unexposed animal. Without prompting, I was able to adequately describe the differences. If I could see them, they must be real.

While it is certainly not clear at this time exactly what the changes in the CSF of the radar workers mean, it does point to a possible new effect of high-level microwave exposure. Unlike the situation with the rabbits, there are no brain tissue samples to study in the humans. Recently, the radar school in Göteborg has instituted substantial changes in its maintenance procedures. A number of safety measures and devices are in place that should prevent anyone from being exposed to operating radar at levels above the human exposure standards. These measures include new standards as well as new interlocks that prevent activation of radar units while personnel are working near the antennas.

This is a area that I will watch. Hansson has promised to keep me informed as he accumulates more data. At the moment, there are only about 11 patients in the sample, and he feels he needs at least twice that many before any concrete statement can be made.

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11/19/84

THIRD INTERNATIONAL CONFERENCE ON WATER AND IONS IN BIOLOGICAL SYSTEMS

by Thomas C. Rozzell.

There has been a long tradition of biophysics research in Bucharest, Romania, going back some 100 years. A number of important international meetings have been sponsored and held by the Biophysics Department of the Faculty of Medicine in the Medical School of the University of Bucharest. The most recent of these, the Third International Conference on Water and Ions in Biological Systems, was held in October 1984. The conference was jointly sponsored by the United Nations Education, Scientific and Cultural Organization (UNESCO), the Academy of Medical Sciences of Romania, the Union of the Societies for Medical Sciences in the Socialist Republic of Romania, and the Romanian Biophysical Society--all in cooperation with the International Union for Pure and Applied Biophysics. A special Symposium on Membrane Transport was organized and sponsored by UNESCO and ONR, London.

Studies of cellular and membrane structure, transport of water and ions across cellular membranes, binding of ligands to proteins and other macromolecules, function and characterization of bound and free water, and analytical methods of analysis have long been an integral part of the Cellular Biophysics Program at the Office of Naval Research, Arlington, Virginia. The understanding of cellular and subcellular structure and mechanisms is crucial to the understanding of the course of disease processes and the healing of wounds due to combat. Much of the medical therapy regime depends on a sound understanding of basic cellular and membrane phenomena.

This 4-day conference was attended by more than 200 persons and featured 223 contributed papers, of which 122 were posters. There were seven invited plenary lectures by distinguished researchers and theoreticians. These usually lasted at least 45 minutes each with rather lengthy discussion periods.

Because of the large number of papers presented, it is not practical to attempt a comprehensive, in-depth review of the entire conference. Instead, I will dwell on what I consider to have been one of the major "threads" that ran throughout the meeting. This had to do with calcium ions--for example, their role in regulating cellular function, their transport into and out of cells, their binding to various sites, and their effect on electrical properties of membranes and channels.

The importance of calcium ions in regulating cellular function and in intra- and extra-cellular "communication" has become increasingly known in the last decade or so. As techniques for studying cellular events become more sophisticated, we are better understanding just how important a role calcium plays in regulating a large number of processes that take place in the cell. As background, remember that the concentration of calcium ions, Ca^{2+} , inside the cell is on the order of 10,000 times lower than the concentration outside the cells. This makes it easy to visualize how calcium can play a major role in regulation; for small changes in the concentration--which is already very, very low (micromolar)--give significant variations around this low level. These variations can be achieved then by picking up or giving off relatively small amounts of the cation to the ambient solution surrounding the target functions.

The problem of membrane transport of calcium in carrying out its messenger or communicator function was addressed by Dr. Ernesto Carafoli (Laboratory of Biochemistry, Zurich) in one of the invited plenary lectures. Carafoli pointed out that the fluctuation (transport in and out of the cell) of Ca^{2+} is achieved by two mechanisms--reversible complexation by soluble (protein) anions, which act as a carrier, and the transport across membranes through channels. Both mechanisms appear to rely on proteins being able to discriminate between Ca^{2+} and other cations that are present in the cells in much higher concentrations (such as K, Na, Mg). According to Carafoli, this may be possible because calcium, with a nonhydrated radius of 99×10^{-12} m, does not place strict demands for octohedral geometry on the protein cavity that complexes it. This is an advantage in dealing with predictably irregular cavities offered by protein folds. The binding and transport of Ca^{2+} by soluble proteins is apparently more efficient in regulating calcium in the different intracellular compartments than from inside to outside. This is probably because the binding to these proteins is limited by the amount of proteins present intracellularly, whereas membrane proteins, although present in small amounts, could still carry out the binding efficiently by transporting one or two ions at a time then "returning" rapidly for the next binding and transport cycle.

Carafoli went on to point out that there are several calcium transporting systems present in eucaryotic cells

(cells with a nucleus) and that this fact underscores the importance of calcium as a carrier of information. Evidently, so much activity in the cell depends on the signaling function of calcium that its regulation became an absolute priority during evolution, and a large number of membrane transporting mechanisms were developed to keep the fluctuations of calcium under strict control.

In another plenary lecture, Professor C.A. Pasternak (Biochemistry Department, St. George's Hospital Medical School, London), discussed the control of membrane permeability by intracellular Ca^{2+} . It is known, for instance, that increases in the concentration of intracellular Ca^{2+} (within the micromolar range) can affect permeability channels in a number of cell types. In excitable as well as nonexcitable cells, for example, potassium channels are opened by Ca^{2+} , while communicating junctions are closed by the ions. Pasternak has been studying the effect of extracellular Ca^{2+} on exogenously introduced permeability channels. (Since extracellular Ca^{2+} is normally constant at a 1 to 2 mM, there is little effect of Ca^{2+} on endogenous permeability channels.) Pasternak reported that he uses a virus to induce permeability changes in cells. The virus, such as Sendai virus or Newcastle Disease virus, at levels of 1 to 100 viral particles per cell does not lyse nonerythroid cells but rather induces a permeability pore that is approximately 1 nm in diameter. This leads to the cell's losing, for example, certain ions, and metabolic intermediates such as sugar phosphates. Although calcium inhibits neither the binding of the virus to the cell nor the subsequent fusion of the virus envelope to the cell membrane, it does appear to prevent the induction of increased permeability. Calcium also appears to enhance the recovery of the normal permeability of cells following an attack by a virus or other toxin. In addition, calcium ions appear to inhibit the leakage of ions and phosphorylated compounds once they have begun to pass through the membrane; that is, it closes permeability pores as well as preventing their opening. While the actual mechanisms of how extracellular calcium affects membrane permeability are not known, Pasternak did speculate on a few possibilities and on the consequences of these mechanisms with regard to clinical modalities.

Although not speaking directly of calcium, Dr. P. Lauger (Department of Biology, University of Constance, West Germany) gave a lucid plenary lecture on

the general mechanisms of ion transport across lipid membranes. As mentioned above, there are two ways in which ions and molecules may be conveyed across membranes: by way of carriers and through channels. Lauger pointed out that the kinetics of the two mechanisms are different, but they are not mutually exclusive; and in many cases, as seems to be the situation with Ca^{2+} , they may occur simultaneously without being competitive.

One of the more innovative papers, and one which may prove to have far-reaching implications, was given by Dr. S. Forsen (Chemistry Department, University of Lund, Sweden). He discussed multinuclear nuclear magnetic resonance (NMR) studies of ion binding in Ca^{2+} binding proteins. He pointed out that although NMR spectroscopy is usually limited to a few magnetic nuclei (mainly ^1H , ^2H , ^{13}C , ^{15}N , ^{19}F , and ^{31}P), it offers many more alternatives. In fact, all essential elements, simple ions included, in biological systems have at least one potentially valuable isotope that is amenable to study.

Improvements in the instrumentation for NMR spectroscopy and the introduction of Fourier transform techniques are now making it possible to study naturally occurring isotopes such as ^{43}Ca , which has a natural abundance of only 0.15 percent. In addition, all simple ions and a large fraction of most biologically interesting elements have magnetic nuclei with an electric quadrupole moment. Such nuclei tended to be avoided by NMR spectroscopists for a long time because the signals were very broad and did not seem to contain much interesting information. But now it seems that progress in this field is revealing that NMR studies of quadrupolar nuclei, in particular nuclei of simple ions like Na^+ , K^+ , Mg^{2+} , Ca^{2+} , and Cl^- can provide unique and valuable biochemical information.

In general, NMR spectroscopy provides information on a number of experimental parameters, such as signal intensities, chemical shifts, relaxation rates, spin-spin couplings, and quadrupole couplings. All these parameters in one way or another depend on the chemical nature of the nuclear environment and on its structure and dynamics. Thus, Forsen feels that NMR spectroscopy may be useful to identify and characterize ion binding sites on biological macromolecules and to follow how these change during a biochemical reaction. He also believes it is possible to study compartmentalization and transport processes between different compartments, binding constants of ions to different

macromolecules, and rates of chemical exchange under equilibrium conditions. NMR should also be able to determine metal ion populations of individual binding sites on a macromolecule with multiple sites. This, according to Forsen, makes it possible to study difficult phenomena such as cooperativity or anticooperativity of ion binding.

After reviewing some of the basic theory and discussing the nuclear properties of $^{25}\text{Mg}^{2+}$, $^{43}\text{Ca}^{2+}$, and $^{113}\text{Cd}^{2+}$, he went on to show how the last-named could be used as a substitute for Ca^{2+} in many systems. Reporting on some of his recent results, Forsen gave details of how he determined the nature of Ca^{2+} ligands in a number of Ca^{2+} binding proteins, studied cooperativity phenomena in Ca^{2+} binding, determined chemical exchange rates for ^{43}Ca or ^{25}Mg in a number of systems, and, finally, observed site-site interactions in multi-site Ca^{2+} -binding proteins.

This was a most impressive paper and leads to speculation that these NMR spectroscopy techniques, if adopted, could provide critically needed information about binding sites in a number of important biological, pharmacological, and immunological areas. NMR spectroscopy is particularly valuable in that it is a nondestructive technique and allows ions to be observed both in space and in time.

The mechanisms that control Ca^{2+} fluxes in mitochondria were the focus of a paper given by Dr. C. Tarba (Department of Biology, Babes-Bolyai University, Cluj-Napoca, Romania). The elucidation of these mechanisms is important for understanding the role of calcium in the metabolic processes of the cell. It has been thought for some time that Ca^{2+} transport in mitochondria is involved in regulating intracellular calcium content as well as different intramitochondrial biochemical and biophysical processes. Tarba presented the problem of Ca^{2+} transport in relation to the process of oxidative phosphorylation and the components of the proton electrochemical gradient. This gradient represents the high energy intermediate between oxidation and phosphorylation.

Tarba pointed out that although it has been known for about 20 years that inorganic phosphate (P_i) releases Ca^{2+} from liver mitochondria, it has only recently been realized that P_i might play a major role in the regulation of Ca^{2+} transport. However, P_i is not the only chemical species important in Ca^{2+} transport. Mg^{2+} has been shown to be important in both the regulation of Ca^{2+} uptake and release. He pointed out that Mg^{2+} is always present in the vicinity

of mitochondria; it is known to be antagonistic with Ca^{2+} . It is known also for its protective role in membrane integrity and the functioning of different ATPases. P_i is also a central metabolite in energy conservation and utilization by the cell.

Dr. G. Walker (School of Biological Sciences, National Institute for Higher Education, Dublin) discussed the regulation of the cell division cycle by Mg^{2+} . Although he has only worked with yeast cells so far, he has found that Mg^{2+} plays a major role in controlling progression from stage to stage during cell division. It was found that cells that are depleted of Mg^{2+} grow abnormally large. Walker speculated that tumor cells may have overridden the cell-cycle controls imposed on normal cells simply because tumor cells possess altered capacities to regulate their intracellular Mg^{2+} concentration. This certainly seems to be an area worth investigating. While Walker did not allude to possible interactions between Ca^{2+} and Mg^{2+} , these must not be overlooked. One well-known hypothesis is that alteration in the major cellular divalent cations (Ca^{2+} and Mg^{2+}) homeostasis might play a predominant role in the pathogenesis of neoplasia or, at least, in the expression of the malignant phenotype.

From a biochemical point of view, Mg^{2+} is known to be involved, more deeply than Ca^{2+} , in the regulation of several enzymatic activities, metabolic pathways, and control phenomena. However, knowledge of its metabolism, compartmentation, and movement at a cellular level is still scanty. So magnesium has been considered a very stable cation in the cell, where its activity depends on the fine regulation of intracellular Ca^{2+} . Dr. A. Cittacini (Institute of General Pathology, Catholic University, Rome) reported on studies of metabolism of Mg^{2+} in cancer cells, with particular emphasis on the relation existing between this cation and Ca^{2+} . Cittacini and coworkers studied the movement of Ca^{2+} and Mg^{2+} in ascites tumor cells in response to the treatment with the antibiotic ionophore A-23187 that is known to promote electroneutral exchange of Ca^{2+} and Mg^{2+} across cell membranes. They showed that Ca^{2+} entry into the cells is strictly dependent on the availability of Mg^{2+} to leave the intracellular compartment, and that the level of free Mg^{2+} is strongly dependent upon adenosine triphosphate (ATP) content.

Some of the most-studied cells in the human body in recent years are those that participate in immunity. The role of Ca^{2+} fluxes in connection with cells that have immunological competence has

the thrust of a paper given by Dr. U. Zelck (Institute of Pharmacology and Toxicology, Wilhelm-Pieck University, Rostock, East Germany). He has conducted research with a group working at the Institute of Sera and Vaccines in Praha, Czechoslovakia. These workers have focused on the Ca^{2+} exchange behavior of neutrophils, thymocytes, and macrophages. They have studied the influence of ATP, plant lectins (mitogens), and the lymphokine transfer factor (TF) on this exchange behavior.

According to the results given concerning the Ca^{2+} transport behavior of normal and activated guinea pig peritoneal macrophages and of normal alveolar macrophages of the guinea pig, TF isolated from human lymphocytes seems to be able to enhance the Ca^{2+} uptake might be one of the first events occurring after contact of TF with the macrophage membrane. They may also be involved in the molecular mechanism of the transfer factor-macrophage interaction.

There were a few additional papers on calcium functions and interactions, but these were the major ones. There was significant evidence that more emphasis is being placed on the regulatory aspects of calcium, magnesium, and other endogenous cations. The results of these and other studies reported at the conference point to the need for continued research in cellular aspects of these important cations.

The symposium sponsored by ONR, London, which consisted entirely of invited papers, also contained several discussions relating to the role of calcium in the regulation of cellular transport. Transport mechanisms were chosen as the theme of the symposium because they are the principal mechanisms that permit cellular function to occur.

The proceedings of the conference will be published early in 1985 by the Romanian Biophysical Society.

11/19/84

NEUROBIOLOGY RESEARCH AT THE MAX PLANCK INSTITUTE FOR PSYCHIATRY

by Claire E. Zomely-Neurath. Dr. Zomely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1986 from her position as Director of Research, The

Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Investigators in the Department of Neurochemistry, Max Planck Institute for Psychiatry, Martinsried, West Germany, are making significant contributions to research on fundamental problems in neurobiology, particularly nerve growth factor (NGF).

The director of this relatively new department is Professor Hans Thoenen, who organized and developed it after relocating from Basel, Switzerland. The laboratory facilities are excellent, as are the research scientists in Thoenen's department. There is close collaboration with the Max Planck Institute of Biochemistry. In addition, a molecular biology-genetic engineering division is now being organized which would be available for consultation and collaborative programs with the other Max Planck institutes in Martinsried.

The rest of this article describes some of the department's research projects; the number and variety of the programs are impressive, especially since the total research group is of relatively modest size. Thoenen can be contacted directly for additional information.

Regulation of NGF

Thoenen and his groups have studied the question of how NGF as a target-derived retrograde trophic messenger may act to generate or maintain innervation patterns in the peripheral sympathetic and sensory nervous system. The approach used was to examine the distribution of NGF both in intact tissues and after perturbation of sympathetic and sensory innervation. This project was not possible until recently due to the insufficient sensitivity and/or reliability of the available assay methods for NGF. The development of a highly sensitive two-site enzyme immunoassay by these investigators allowed the direct quantitation of NGF levels *in vivo* in intact tissue. The NGF levels in target organs were found to be correlated with the density of their synaptic innervation. Using this sensitive assay technique, evidence was also obtained for retrograde axonal transport of endogenous NGF from the periphery. They also used the isolated rat iris as a model target tissue of the sympathetic nervous system. In this system, NGF synthesis as well as release could be quantitatively determined. In addition, the effects of denervation could be studied. The results obtained are consistent with the release of an inducing signal by degenerating nerve terminals,

and this NGF induction was shown to be dependent on RNA synthesis.

Cloning cDNA

A study comparing complementary DNA (cDNA) or genomic DNA derived from the known amino acid sequences of NGF from various species is being pursued actively. The object of this study is to obtain information on the active center of NGF. Previous work from Thoenen's lab showed that the biological activities of two NGFs (mouse and bovine) were identical but were different immunologically. This finding indicated that the active center of NGF remained highly conserved, whereas parts of the molecule determining immunological properties changed during evolution.

NGF-Messenger RNA

Another project of importance is the quantification and localization of NGF-messenger RNA (mRNA) for the purpose of defining the site of NGF synthesis. Previous work indicated that the sites of highest NGF activity are not always the sites of highest synthesis. To obtain definitive information, one must develop highly sensitive hybridization methods as the amounts of NGF in peripheral tissues are extremely low. The results obtained showed that the NGF-mRNA levels correspond to the NGF protein levels in the peripheral target tissues, whereas in sympathetic ganglia, NGF-mRNA is barely detectable. These findings support the concept that high levels of NGF in sympathetic ganglia result from retrograde transport rather than from local synthesis. Identification of cells which synthesize NGF-mRNA by *in-vitro* hybridization in tissue sections and cultured cells showed, in preliminary results, that strong signals were present not only in tubular ducts of the mouse submandibular glands (known to synthesize large amounts of NGF) but also in iris cells.

Site of Action of NGF

Evaluation of the site of action of NGF and the possible involvement of proteolytic degradation products of NGF for the induction of choline acetyltransferase revealed that: (1) a direct regulatory action of NGF within the cytoplasm and in the nuclear chromatin could be excluded, and (2) the induction of the enzyme, choline acetyltransferase, was not due to proteolytic fragments of NGF.

Enzyme Induction

A study of NGF-mediated enzyme induction and cell contact-mediated enzyme induction is also being done.

Little is known about the molecular mechanism of NGF action and about how the initial interaction of NGF with its receptors is linked to early, intermediate, or long-term biological effects. In addition, little is known about whether these effects are related to one another, or whether they are mediated by the same or different second messenger mechanisms. It has been shown *in vivo* that in the adrenal medulla NGF selectively induces key enzymes in catecholamine biosynthesis--i.e., tyrosine hydroxylase (TH) and dopamine B-hydroxylase (DBH)--with no effect on dopa decarboxylase (DDC) or monoamine oxidase. Thoenen and his group are using primary cultures of adrenal medullary cells as a model system. These cultures are composed of 85 to 95 percent chromaffin cells, are maintained in a serum-free medium, and are not dependent on NGF for survival. Similar to its effects *in vivo*, NGF--using the model culture system--also mediates the specific induction of the key enzymes in catecholamine biosynthesis (TH, DBH) and phenylethanolamine-N-methyltransferase (PNMT), while DDC is unaffected. Recently, the investigators found that the induction of these three enzymes involves a post-transcriptional, poly-adenylation-dependent event. This implies that mRNA processing may be involved in NGF's mechanism of action. Further studies are being directed toward a more detailed level of analysis of the effect of NGF on TH-mRNA. To this end, the investigators are presently involved in isolating a cDNA probe as a tool. They plan to work with isolated chromaffin cell nuclei to establish the temporal sequence of events associated with the effect of NGF on the maturation of TH-mRNA precursors. Thoenen and his group also found that TH levels could be regulated by cell density in their culture system and developed a procedure in which the effect of cell density on TH, DBH, and PNMT could be related to cell density--i.e., induced by direct cell contact. They are now investigating the specificity of this phenomenon at the molecular level.

Central Nervous System

A study of great interest is that of NGF in the central nervous system (CNS). Thoenen's group found that only the cholinergic cells in certain areas of the CNS displayed NGF receptors and retrograde transport. Using cDNA hybridization techniques they have recently found that NGF-specific mRNA of the correct size was present in the CNS. They are now investigating the exact sites of NGF production and the physiological role of NGF in the CNS.

BDNF

The brain-derived neurotrophic factor (BDNF) has been recently purified by the Thoenen group from mammalian brain. This factor is able to keep neurons alive in culture and to stimulate fiber outgrowth as does NGF, but it is different from NGF. Monoclonal antibodies against BDNF have been selected and characterized. Experiments are in progress to assess the usefulness of these monoclonals as affinity reagents and tools for immunocytochemical studies.

Trophic Factors

Thoenen's group has shown that in addition to soluble survival trophic factors for development of peripheral neurons *in vitro*, the extracellular matrix also plays a crucial role. Although the matrix alone does not permit neuronal survival, it does increase the sensitivity and efficacy of sympathetic neuronal survival response to NGF, indicating that as yet undefined molecules of the extracellular matrix play a role in neuronal survival. To investigate this phenomenon, the researchers have raised antisera that specifically block neurite outgrowth and survival and that help purify the molecules responsible. In addition, a model protein of the extracellular matrix (the basal membrane protein termed laminin) has been investigated for its effect on neurons of the CNS. The objective was to determine what environmental molecules (in the absence of basal laminae and laminin in the CNS) interact with neurotrophic molecules to maintain these neurons.

Neuron-Glial Interaction

Neuron-glial interaction in the central versus the peripheral nervous system is actively being investigated. The life-long capacity for regeneration in the peripheral nervous system contrasts markedly with the total lack of regeneration observed in the CNS of all higher vertebrates. Recent *in-vivo* experiments have indicated that the crucial factor is the environment rather than the neurons themselves. Underlying mechanisms could involve extracellular substrates and matrices, specific cell-cell interactions, and trophic factors. The investigators have combined approaches to this problem on two different levels: (1) dissociated cell cultures, "chamber cultures" where neurons can choose between sciatic or optic nerve explants as substrates for neurite growth, and (2) *in-vivo* studies, with the aim of defining the cell types responsible for the inhibition of axon growth in the CNS and evaluating the

role of NGF, BDGF, and substrate components.

These investigators have found that even under optional trophic conditions (NGF), sympathetic axons do not grow into optic nerve explants, whereas they grow and elongate well into and through sciatic nerves. Cocultures of central or peripheral neurons with dissociated optic nerve non-neuronal cells showed two different kinds of interaction. Fibroblasts and protoplasmic astrocytes represent a good substrate for the neurons and their axons and "classical" oligodendrocytes classified by morphological criteria as well as by galactocerebroside immunoactivity also associated with the neurite bundles. In contrast, a cell with long, radial processes which is galactocerebroside and 04 glial antigen positive and glial fibrillary acidic protein-negative under their culture conditions strongly inhibits neurite growth in its territory, forming what Thoenen terms "windows" in the dense axonal network. These investigators are carrying out further characterization of this glial cell with the aim of correlating this *in-vitro* behavior with the situation in optic nerve explants and *in vivo*.

Precursor Cells

The Thoenen group is also investigating glial-neuronal precursor cells and the development of neuronal subpopulations. A cell type has been characterized in the ciliary ganglion of the embryonic chick which contains receptors for NGF and a high affinity uptake for catecholamines, properties which are characteristic for differentiated adrenergic neurons. These cells also express the glial-specific 04 antigen, which is recognized by a monoclonal antibody. The proportion of 04-positive cells which simultaneously express neural properties decreases during development, suggesting that these cells are precursor cells for both neurons and glial cells.

Thoenen and his group have shown recently that the same properties are present not only in the parasympathetic ciliary ganglion, but also in sensory and in sympathetic ganglia as well as in the sciatic nerve. During development, norepinephrine (NE) uptake and NGF receptors were found to be lost sequentially, indicating a sequence of differentiation steps from cells which have 04 antigen and both NGF receptors and NE uptake to cells which have only 04 antigen and later become positive for galactocerebroside.

After demonstrating the widespread occurrence of these cells with neuronal and glial properties, the investigators

established a system to analyze the developmental potential of defined cell populations *in vivo*. They are now able to routinely transplant ganglia (intact or dissociated) of the peripheral nervous system of the quail into the migration pathway of neural crest cells in 2-day-old chick embryos. The quail cells are relocated in frozen sections, and the cell type is determined by staining with cell-type-specific antibodies. This technique is being used first to analyze the developmental potential of the non-neuronal cells in the sciatic nerve. In parallel with this *in-vivo* test system, they are analyzing the properties of these cells under different culture conditions with the aim of determining conditions which allow either differentiation to glial cells or to neurons.

In analyzing the mechanisms responsible for neuronal survival and differentiation, Thoenen and his group followed, quantitatively, the development of specific neuronal markers *in vivo*, observed how NGF affects this development, and then tried to correlate the presence of markers defining subpopulations of neurons with their requirements for survival in culture. The researchers found that the development of different markers followed a distinct pattern, indicating that differing mechanisms are responsible for their regulation even when two of the markers were shown by immunohistochemistry to be in the same neuron. By culturing the neurons dissociated from the sympathetic ganglia, it was shown that a correlation existed between neuronal subpopulations defined by their survival requirements *in vitro* and by their neurotransmitter-related phenotypes. This correlation is significant as it shows that the requirements for survival in culture reflect the neuronal phenotype. Indeed, survival-factor requirements could themselves be regarded as a neuronal property arising during differentiation.

Regulatory Mechanisms

A research group headed by Dr. D.W. Huttner of the Department of Neurochemistry is concerned with molecular regulatory mechanisms. This group has identified in sympathetic neurons a phosphoprotein of 70,000 molecular weight that is regulated by NGF and by depolarization. Recent results indicate that sympathetic neurons respond to NGF within 5 minutes with the dephosphorylation of a major 70,000 molecular weight cellular phosphoprotein. This effect of NGF is not mimicked by cyclic adenosine monophosphate but a dephosphorylation of this phosphoprotein similar to that

induced by NGF is seen upon depolarization of sympathetic neurons. Depolarization had been shown by Thoenen and colleagues to promote the survival of sympathetic neurons in the absence of NGF. Thus, the results raise the possibility that dephosphorylation of the phosphoprotein is involved in the NGF-promoted survival of sympathetic neurons.

Another aspect of molecular regulatory mechanisms studied by Huttner and his group is tyrosine sulfation of proteins. They had found previously that tyrosine sulfation occurs in every tissue they analyzed and that it is found throughout the animal kingdom--and even in organisms as simple as the green algae *Volvox carterii*. The widespread occurrence of tyrosine sulfation of protein suggested an important biological role for this modification in cell function.

Two approaches have been used to identify the biological function of tyrosine sulfation of proteins. One approach was to study the enzymes catalyzing tyrosine sulfation in order to develop means of specifically manipulating tyrosine sulfation of proteins in intact cells. They have found an enzyme that transfers sulfate from 3-phosphoadenosine 5-phosphosulfate (PAPS) to tyrosine residues of proteins and have designated this enzyme as a tyrosylprotein sulfotransferase. This enzyme sulfates the same proteins in a cell-free system that are tyrosine-sulfated in intact cells. It is a membrane-bound enzyme and has its highest specific activity in subcellular fractions enriched in Golgi membranes. This enzyme has been solubilized in active form and is currently being purified.

The second approach was to study the tyrosine-sulfated proteins themselves in order to find a possible common denominator for the occurrence of tyrosine sulfate in proteins. All the tyrosine-sulfated proteins and peptides identified by Huttner and his group share a common property--they are secretory proteins. The researchers also found that when sulfate incorporates into proteins, tissue protein (which comprises proteins of all subcellular classes) gives a value of less than 10 percent, while plasma protein (mostly secretory proteins) gives a value of more than 60 percent. Since proteins destined for various subcellular locations (membrane, lysosomal, secretory) pass through the Golgi complex, it is interesting that tyrosine sulfation, in contrast to other modifications such as glycosylation or carbohydrate sulfation, may occur only in secretory proteins.

Since the known tyrosine-sulfate proteins as well as some recently found by Huttner and his group include functionally quite diverse secretory proteins, it is possible that the significance of tyrosine sulfation does not lie in the performances of these different proteins after their secretion; but tyrosine sulfation may be a common aspect of their intracellular transport and maturation. Therefore, the current working hypothesis of Huttner and his group is that tyrosine sulfation serves as a sorting signal for certain secretory proteins.

Additional projects being studied involve: (1) group cell motility, including research directed toward an understanding of cytoskeletal assembly mechanism concerned with actin and actin-binding proteins which play an important role in cell motility; and (2) neuronal gene expression with projects on synapsin I protein (a membrane protein) and cDNA cloning, G-substrate cDNA cloning, and monoclonal and molecular characterization of choline acetyltransferase the acetylcholine-synthesizing enzyme, in order to have a reliable marker for cholinergic neurons. Since acetylcholine is a major neurotransmitter in the nervous system, this project is of fundamental importance in studying neuronal function.

The significance of the research being carried out by Thoenen's group is not only the excellent quality of the projects but also the multifaceted approach of elucidating the mechanisms involved in neuronal function which incorporate the application of the techniques of molecular biology and genetic engineering. These methods are only beginning to be used by neuroscientists, and Thoenen's group is making major contributions in the application of such techniques to study problems in neurobiology.

11/8/84

COMPUTER SCIENCES

TURING INSTITUTE SERVES INDUSTRY

by J.F. Blackburn. Dr. Blackburn was until September Liaison Scientist for Computer Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is now the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.

The Turing Institute in Glasgow, Scotland, maintains a large library of software for industrial customers. The director of the institute is Professor Donald Michie, formerly head of the Machine Intelligence Research Unit at Edinburgh University. He established the institute in July 1983 in Edinburgh and moved to Glasgow in September 1984.

The institute was named for Alan Turing, the British mathematician whose work had an important influence on computer science and machine intelligence. The objectives of the institute, according to its charter, are "to advance the education and knowledge and thereby the social improvement of the public in general and industrial and technological concerns in particular by means of carrying out research, development, teaching, and other scientific work in connection with machine intelligence and computer technology and the publication of results of such research."

Much of the recurrent funding of the institute is provided by industry through the Industrial Affiliates Scheme, which provides a variety of technology transfer services to affiliates. These services consist of training, information, and software. The training programs offered under the affiliates scheme are designed to provide basic instruction in the design and use of advanced software tools, and to keep affiliates up to date with recent developments in advanced information technology, with particular reference to fifth-generation-computer topics.

The institute has an extensive information service available to affiliates. The primary role of its library is to provide an information service for industrial affiliates and for members, employees, fellows, and associates of the institute. A collection of specialized material on expert systems, robotics, and computer vision is being built up.

Four categories of software are available to the institute's affiliates: Turing Institute software, public domain software, Intelligent Terminals Ltd. software, and evaluation packages.

Software Languages, Application Generators, and Shells

The main languages used at the institute are listed in Table 1; applications, generators, and shells are listed in Table 2. The institute also has a wide range of utility packages for use in production of prototype software. Included are cross-reference tools, input/output packages, debuggers, and list handling routines.

Table 1
Software Located at the Turing Institute

PROLOG:	C PROLOG runs on a Digital Equipment Corporation VAX 11/750 and is compatible in syntax and functionality with DEC-10 PROLOG.
LISP:	The Franz LISP system runs on a VAX 11/750 and includes a compiler and an interpreter.
POP-2:	This language runs on a PDP 11/24 under the UNIX operator.
FP:	This functional programming language designed by John Backus of IBM runs on the VAX 11/750.
POPLOG:	This is an integrating software system containing a powerful editor and the languages POP-2, LISP, and PROLOG.
OTHER:	Other languages running on the VAX 11/750 include C, PASCAL, and FORTRAN.

Application Generators

Two software packages for building expert systems are described below.

EX-TRAN 7 (Expert Translator). This is a FORTRAN-based software package for building expert systems. Its features include the following:

1. Single and clear rule-based solutions are generated for the target problem.
2. Flexible rule structuring allows hierarchical dependency to be established between rules. Rule structure is controlled by the user from a text file.
3. External FORTRAN subroutines can be linked with the expert system for capturing data, supporting the attribute testing component of "if-then" rules, or triggering action sequences from the "then" component. Such external routines can also support intermediate calculations necessary in the course of executing rules.
4. Rules for the problem can either be directly supplied to EX-TRAN 7, or they can be inductively inferred by EX-TRAN 7 from user-supplied sample decisions using the system's inductive learning module.
5. EX-TRAN 7 automatically generates FORTRAN 77 code representing the rules to be used in the final run-time expert system.
6. User commands are available for interactive guidance of the system at all stages of its operation.
7. The operation of the resulting expert system incorporates an "explain on demand" facility.

Expert systems built with EX-TRAN 7 have useful commands for consultation. The rule under execution

can be displayed in natural language form with a marker indicating the current position of execution reached. Users can, at any time, pose "why" and "how" questions to the system concerning decisions reached. A decision log is kept, and users can write their own notes or request the printing of the rule under execution to the decision log file.

The commands available to the domain expert during system construction and run-time commands for the nonexpert or semi-expert user aid in the development of expert systems.

Rulemaster, Radial, and Rulemaker. A new expert-system-building kit called Rulemaster uses an inductive rule generator (Rulemaker) and a rule language (Radial) to implement a hierarchically ordered system of inductive learning for the acquisition of expert knowledge.

Rulemaster has been tested in a real-world situation in a prototype expert system for severe-storm forecasting. Meteorologists use a large number of rules for analyzing and interpreting data, and these rules are often unstated or poorly understood.

The system was tested in the US, where, on average, there are 10 to 20 severe storms each day. A severe storm has one or a combination of the following characteristics: (1) rainfall greater than 2 inches per hour; (2) intensive lightning; (3) wind gusts greater than 50 knots; (4) tornadoes; and (5) hailstones more than three-quarters of an inch in diameter.

The main preconditions for severe storms are available moisture, rising air, and dry air overlaying moist air. The presence and strength of these conditions, together with various other factors, can be used to predict the

Table 2
Application Generators and Shells

PARAPIC:	An interactive high-level vision language to drive parallel array processors based on POP-2.
CLR:	An expert system generator that produces a rule base by induction from examples. The rules are hierarchically structured, and the system allows simple extension, updating and maintenance of rules.
PDL:	An interactive process description language which has been integrated with an inductive rule generator to form the commercial Rulemaster system.
YAPES:	Standing for Yet Another PROLOG Expert System; an expert system shell written in PROLOG providing a full range of explanation and debugging facilities.
ACLS:	Stands for Analogue Concept Learning System; an inductive rule acquisition package that has been successfully applied to programing tasks unmanageable using other techniques.
AL/X:	A PASCAL-coded expert system shell, originally based on the PROSPECTOR system.
EX/TRAN:	A FORTRAN-based package for inductive acquisition of rules, with a sophisticated shell for their run-time use together with "explain" facilities.
EXPERT EASE:	An inductive learning package running on IBM PC. Available to affiliates by arrangement with its publishers, Export Software International.
CHAT-80:	A database system with a natural language front-end written in PROLOG.
CONCURRENT PROLOG:	An implementation, in PROLOG, of a concurrent PROLOG.

probability and type of severe storm occurrences. Meteorologists use rules to relate various clues to these preconditions, and other rules to relate raw data to clues. Invoking a rule often involves computing.

The severe-storm expert system is organized as a hierarchy of rules, most of which are induced from examples. There are rules to determine the weather state: stable, unstable, or possible tropospheric warming. There are other rules to be applied when the state of the weather is unstable or when there is possible tropospheric warming.

The expert system was field tested in the US during 1984. From 22 through 29 May, five severe storms passed through a region including west and central Texas, Oklahoma, and Colorado. The forecast of the expert system was based on the same data and forecasting approach as the convective outlook forecast of the National Severe Storm Forecast Center (NSSFC). For the test, the forecast of the expert system was compared with that of the NSSFC. The

expert system was correct in four of the five cases, whereas the NSSFC was correct in three. The lead time of the forecasts was 6 to 9 hours.

The Radial language integrates the elements of control and expert rules in a natural way. Its syntax has only 14 keywords but supports features such as generic modules, abstract data types, and an incremental grammar. This support is highly desirable for producing large coordinated expert systems. The language can be used to produce complete Radial programs by way of induction files only. The meteorology application demonstrates that experts find it easier to express their knowledge by way of examples. Such systems are also easier to maintain since program behavior can be corrected by counter-examples rather than by attempts to rewrite code.

Conclusion

The high quality of the machine intelligence work at the Turing Institute together with its close association

with industrial laboratories will have a positive effect on the industries concerned. To the extent that machine intelligence becomes important in the marketplace, these companies will profit from the association. Since affiliation with the institute is not limited to the UK, its influence will play a part in the various applications of machine intelligence in other countries as well. Such applications will include robotics, expert systems, and vision systems.

10/22/84

ENGINEERING

SURFACE-SHIP CONTROL FEATURED AT UK MEETING

by C.J. Holland. Dr. Holland is the Liaison Scientist for Applied Mathematics/Computational Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until December 1985 from the Office of Naval Research, Arlington, Virginia, where he is the Deputy Division Director of the Mathematical Sciences Division.

The subject of ship controls spans a wide range of topics from control and surveillance of machinery to platform control, including maneuvering, stabilization, and steering. Every 3 years since 1966 a symposium has been held on these topics; the seventh was at the University of Bath, UK, from 24 through 27 September 1984.

Symposium Overview

The meeting was attended by more than 300 participants from a dozen countries: the US, the UK, Australia, Canada, India, West Germany, The Netherlands, Sweden, Norway, Denmark, Japan, and Spain. Sixty unclassified technical papers were presented from representatives of governments, navies, industries, and universities. Participants from the US presented 20 talks; the UK, 13; The Netherlands, nine; and Canada, six. The number of US talks has declined almost steadily from a high of approximately 40 at the first conference in 1966. Proceedings were distributed at the meeting. A limited number of copies are available at £40 from the Seventh Ship Controls Symposium, Ministry of Defence, B Block, Foxhill, Bath BA1 5AB,

England. The next symposium is scheduled for The Netherlands in 1987.

The talks dealing with dynamical platform control concentrated on the control of surface ships; several unconventional hull designs were discussed. In this short overview, I will concentrate on a few talks that represent application of control and filtering theories to ship control problems; these theories originally were developed for aerospace applications over the last two decades. The talks were for the most part of an evolutionary rather than revolutionary nature. Nevertheless, they help indicate the difficulties in ship control (such as identification and estimation of hydrodynamic coefficients, including added mass) which are not present in aircraft control.

Symposium Highlights

Professor J. van Amerongen (Delft University of Technology, The Netherlands) discussed his control modeling of rudder-roll stabilization systems. In this concept the rudder is used to simultaneously control yaw and roll; thus the active fins normally used for the control of roll can be eliminated. Since the rudder is the only input available to control the two outputs, the interaction of yaw and roll must be taken into account. The yaw and the roll can be decoupled by restricting low-frequency rudder motions to control yaw while restricting high-frequency rudder motions to roll reductions. The latter is also necessary due to the nonminimum phase character of the roll response. The design of appropriate filters is an essential part of the controller design. A low-pass filter has to be designed to estimate the low-frequency components of the yaw motion, and a high-pass filter has to be designed to estimate the high-frequency components of the roll motion. This research has been carried out in cooperation with the Royal Netherlands Navy with full-scale trials. The Royal Netherlands Navy is currently considering application of a rudder-roll stabilization autopilot to a new class of frigates.

Professor van Amerongen's results show that rudder-roll stabilization is able to realize roll reductions comparable to those based on the conventional use of fins. Economically, there is a trade-off. Rudder-roll stabilization will require a more expensive steering machine due to the higher rudder speed required. However, the expensive fin hydraulics and their control equipment are no longer necessary.

Professor Mogens Blanke (Technical University of Denmark) discussed his use

of the Ljung innovations filter for identifying parameters associated with the added resistance due to steering, hull resistance, and propeller efficiency of ships which are present in the nonlinear equations for the ship's forward speed and propulsion dynamics (Ljung and Söderström, 1983). The Ljung innovations filter is a combined state- and parameter-estimating algorithm which is derived from the extended Kalman filter. It has good properties for estimating parameters without bias and has guaranteed convergence when applied to linear systems. However, in this problem the speed dynamics are nonlinear in the states. The dynamics are, however, linear in the parameters, and Blanke suggested a method for adapting the Ljung filter in this case. This method has been tried on actual sea-trial data.

The identification of the coefficients in the ship-speed equation are of interest over a wide field of marine applications. Good parameter estimates from identification of steering dynamics are essential for the proper performance of an adaptive autopilot. These parameters are equally important for assessing the performance of an autopilot with respect to fuel economy, because the indirect estimation of steering losses is entirely dependent on the coefficients in the equations describing the propulsion dynamics.

Dr. F. Caldeira-Saraiva (British Ship Research Association) discussed vertical motion control of a SWATH (Small Waterplane-Area Twin Hull) craft by the active control of horizontal fins attached to the underwater hull. He used advanced-frequency-domain multi-variable techniques for the design rather than a state-space approach. He made this choice because the hydrodynamic behavior was extremely complicated and was described by differential equations with frequency-dependent coefficients. The frequency dependence occurs since the description of the hydrodynamic system is usually obtained in terms of its response to regular trains of waves (single-frequency sinusoidal inputs).

Interest in the SWATH stems from its ability to provide platform steadiness and sustained speed capability in waves. It has the potential to be a superior platform for aircraft operations. The US Navy, the Canadian Navy, the British Navy and the Japanese ship-builder Mitsui are among those interested in SWATHs.

Conclusion

Control and filtering ideas developed over the last two decades, origi-

nally developed for aerospace applications, are beginning to be used in ship control problems. For the potential of these methods to be realized, an effective liaison between the control and hydrodynamic modeling communities must be established.

Reference

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11/5/84

MATERIAL SCIENCES

DEVELOPMENTS IN THE TECHNIQUES AND TOOLS FOR MICROANALYSIS OF MATERIALS AT THE UNIVERSITY OF OXFORD

by Kenneth D. Challenger. Dr. Challenger is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

The Department of Metallurgy and Science of Materials at the University of Oxford is one of the premier materials-science departments in the world. Sir Peter Hirsch, head of the department, returned full-time to Oxford last October after 2 years as the part-time chairman of the UK Atomic Energy Authority. Under his leadership, the materials department at Oxford has become the center of excellence for electron microscopy in the UK.

The department has many materials-research activities worthy of attention, but this article is devoted to their recent developments in the tools and techniques for microanalysis. There have been developments in several areas recently: high-resolution electron microscopy, scanning transmission electron microscopy, acoustic microscopy, low-voltage scanning electron microscopy, digital image processing, and atom-probe microanalyses.

High-Resolution Electron Microscopy

The most recent development in this field is that Oxford and JEOL, Ltd., of Japan are collaborating in the design and production of a 400-keV high-resolution transmission electron microscope

(TEM). The principal goal in the development of this instrument is to achieve a resolution of about 0.12 nm, which, if successful, will allow the direct observation of silicon atoms (lattice parameter of 0.136 nm). This instrument will have a better resolution than the recently built Atomic Resolution Microscope located at the US National Center for Electron Microscopy, Berkeley, California (theoretical resolution of 0.13 nm, but demonstrated resolution of 0.16 nm at 1 MeV). The desire to resolve individual Si atoms has an obvious motivation with respect to advancing the fundamental knowledge of semiconducting materials. There is very healthy mutual competition and respect between the Oxford group and Thomas' groups at Berkeley. Oxford's reputation in the field of microscope design has resulted in many similar collaborative projects in which the result for Oxford has been the prototype instrument whose design is the basis for a commercial instrument by the collaborators. Thus the Oxford group acquires these sophisticated instruments for a fraction of the cost that the next buyer must pay.

Scanning Transmission Electron Microscopy

Dr. E.D. Boyes and coworkers have constructed a high-resolution scanning transmission electron microscope (STEM). It operates up to 80 keV, has an ultra-high vacuum field emission electron gun and a routine resolution of 1 nm. It is primarily an analytical instrument with facilities for high-sensitivity x-ray microanalysis, electron diffraction, and electron spectroscopy from very small (less than 1- to 2-nm diameter) selected areas. Structural examination in bright field can be combined with high-resolution crystallographic and chemical analyses with this instrument. It is presently being modified so that the operator can simultaneously view an electron diffraction pattern and a bright field image. This is very commonly desired when attempting to obtain crystallographic and chemical analyses from very small particles or very small regions in a sample. This dual viewing is not possible with existing STEMs.

Boyes plans to use this instrument with the new modification to study supported metal catalysts. The structures of these small particles (less than 5 nm in diameter) may be important in both the reactivity and sintering behavior (a cause of deactivation) of the catalyst.

Low-Voltage Scanning Electron Microscope

Boyes is also the principal investigator for the design and fabrication

of a high-resolution, low-voltage scanning electron microscope. This work is supported by the US Army Research, Development, and Standardization Group, London. The motivation for this project is that generally small electron probes are needed for high resolution (5 to 20 nm) and it is much easier to achieve this with high accelerating voltages (20 to 100 keV). At these high accelerating voltages the secondary electron yield is quite low (<0.1 for most materials), leading to severe surface-charging problems with nonconducting specimens. The images of the specimens are consequently of poor quality (the resulting resolution is in excess of 100 nm). However, at lower accelerating potentials, 0.1 to 5 keV, the secondary electron yield is essentially unity, and the surface charging does not occur. Thus, the task is to design an instrument that will retain the high resolution of the high accelerating potential instrument but operate at 0.1 to 5 keV. Boyes believes that his design will achieve a resolution equal to or better than the high-voltage instruments while operating at 1 keV. The essential features of his instrument are the combination of a high-brightness and low-energy-spread field-emission electron gun (capable of operation up to 30 keV), with a high-quality lens and stage assembly in a very short (6 cm), mechanically rigid and magnetically screened column. The gun chamber is fully high vacuum (10^{-10} torr), and the whole system is bakeable. Extremely low aberration coefficients (e.g., $C_s=0.27$ mm and $C_c=0.4$ mm) are possible in a conventional symmetrical condenser-objective probe lens operated in an enhanced second-zone mode. The collection of the secondary electrons will be very efficient with space in the specimen region for specimens up to a few millimeters in thickness.

When complete this machine will have several limitations, which result from the fact that many off-the-shelf components are being used to minimize the cost. If the expected resolution at low voltages is attained, these limitations can easily be eliminated (namely, the minimum magnification possible--at present it may be as large as 1000x; and the specimen size--at present only small samples can be examined).

This instrument will be a powerful tool for the research on semiconductors and other nonmetallic materials. The instrument should be in operation by early 1985.

Digital Image Processing

Dr. E.E. Doyes now has on-line digital image processing and analysis

for most of the metallurgy department's microscopes. Intellect 100 and 200 digital frame-store image memories (a dedicated bank of random access memory) are used to fill a standard 50- or 60-Hz TV frame. The memories have an input digitization to 8-bit precision, which gives 256 levels of grey (normal CRTs give about 16 or 32 levels of grey) with sampling rates of 10 MHz for 512x512 pixels. The data paths through the system are under computer control, or software programmable, or both. The DEC PDP 11 23 can be used in both a control function and for more complex data processing. Methods of manipulating images in digital form in order to extract more data from them are under investigation. By using the system on-line, the researchers have created new possibilities for interactive control on a quantitative basis. When speed of processing is needed, such as for high-resolution TEM, the computer software is used to control the dedicated hardware, including the frame-store image memories. The bulk storage includes RX02 floppy disks and a Winchester fixed hard disk unit.

This image storage and processing system is presently interfaced with a JEOL 200CX high-resolution TEM, several scanning electron microscopes, the high-resolution STEM and, to a more limited extent, an acoustic microscope (limited in that the images must be recorded on disks and then read into the Intellect system due to the large distance separating the microscope and the frame-store system).

The Intellect 200 system includes a comprehensive image-simulation program. This, with dual-screen viewing, allows the actual high-resolution image to be viewed simultaneously with a simulated image, greatly assisting the interpretation of high-resolution images. This makes these experiments much more straightforward to perform.

Acoustic Microscopy

The acoustic microscope was developed by Professor C.F. Quate of Stanford University about a decade ago. The development of this tool represents yet another nonoptical probe for obtaining quantitative information at a microscopic level (electrons, x-rays, ions, and heat radiation all represent other non-optical probes used in microscopic examinations). In contrast to electromagnetic radiation/object interactions, which are a function of the dielectric properties of the object, the interaction between sound and the object is strongly influenced by the *elastic* properties of the object.

The relationship between the wavelength of the information carrier (for example, electrons or photons) and the theoretical resolution possible, which is used for electron and optical techniques, also applies to sound. On the basis of these relationships, ultrasonic frequencies on the order of 1 to 2 GHz are required before the resolving power of the acoustic microscope reaches that of an optical microscope ($\sim 0.5 \mu\text{m}$). Modern piezoelectric transducer technology is capable of satisfying this requirement, but not without some difficulty. The ultrasonic waves are emitted by the piezoelectric material (usually ZnO) into a lens (usually sapphire) which has a spherical cavity engraved on the side nearest the object in order to focus the acoustic beam. The acoustic coupling to the object is generally accomplished with warm water (several trade-offs must be considered in this choice). When the water is heated, the attenuation of the acoustic beam by the water decreases rapidly due to the temperature dependence of the viscosity of the water (an attenuation of about 60 dB at room temperature can be decreased to about 30 dB by heating to 60°C). Attenuation of the sound increases as the length of the acoustic path increases; therefore the smallest possible radius in the cavity of the sapphire lens is called for. This transducer arrangement also acts to receive the ultrasonic signals coming from the object and converts them into electromagnetic signals which are then used to form the image.

The microscope can be used in either the transmission (low frequencies) or reflection mode. In the reflection mode it is possible to focus the beam onto a plane below the surface of the specimen, forming an image of that subsurface region.

Pulses of sound are used to create wave packets in time intervals corresponding to the path length in the sapphire lens, the water, and, when imaging subsurface regions, the path length in the object. The time interval between pulses must be long enough for the reflected signals to return to the transducer between the pulse (this is generally on the order of 100 ns). The transducer is scanned relative to the sample, and the image is played on a persistent screen identical to the type used in standard scanning electron microscopes. At Oxford the image can also be digitized and stored for later analysis with the Intellect digital frame-store system.

The contrast in the acoustic image from the reflection operation mode

results mainly from variations in the elastic properties within the material. In the transmission mode, the variation of the attenuation of the incident beam (by absorption or by scattering in a direction other than that of the incident beam) forms the contrast observed in the acoustic image.

At Oxford the acoustic microscope has been used to study the integrity of diffusion bonds in steel sheets (in the transmission mode at 140 MHz), the interfaces of hard metal coatings, oxides, and soldered joints. Briggs and his coworkers have shown that plastic deformation causes an alteration of the ultrasonic properties of metals. Dislocation damping and scattering by voids are being studied with the aim of imaging plastic zones around crack tips. The Oxford group is investigating the idea of a quantitative elastic microprobe using the potential of the acoustic microscope to make quantitative measurements of complex elastic properties. They have also developed a theory to explain why surface breaking discontinuities such as fine cracks give such strong contrast in the reflecting acoustic microscope--even though the defects are much less than a wavelength wide. Other topics under study include demineralization of human teeth, solidification processes, order-disorder transformations, and applications to the study of biological materials.

I do not believe the scanning acoustic microscope will replace either the optical or the electron microscope for the study of crystalline solids; I consider it merely a complementary tool by which additional information can be gathered. Its main application may in fact turn out to be as a nondestructive testing method for thin films (where standard ultrasonic inspection methods have severe limitations).

Most of the effort at Oxford appears to be on developing techniques and applications for the instrument rather than developing the instrument itself. Quate and his group at Stanford continue to develop the instrument and have licensed Leitz to build and sell their design. Both Leitz and Olympus produce acoustic microscopes commercially.

Field Ion Microscopy and Atom Probe Microanalysis

Dr. G.D.W. Smith and coworkers have developed in collaboration with V.G. Scientific a combination field ion microscope with a time-of-flight mass spectrometer which will permit the identification of individual atoms imaged in the field ion microscope. The instrument, the FIM100, was only recently completed at Oxford and is available commercially from V.G. Scientific. As of this writing, two other instruments have been sold--to IBM and the Oak Ridge National Laboratory in the US.

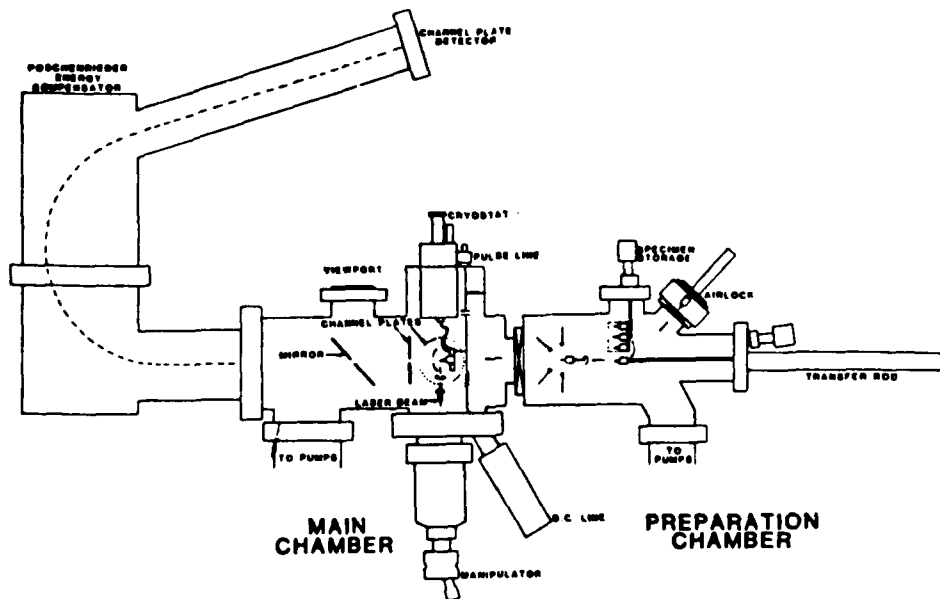


Figure 1. FIM 100 vacuum system (from G.D.W. Smith et al., "The FIM100--Performance of a Commercial Atom Probe System," paper presented at the 31st IFES, Paris, France, 1984).

Both high-voltage and laser pulsing are possible, allowing the instrument to be used to study both conducting and nonconducting materials. Figure 1 illustrates the system. It is equipped with timing and control electronics and full on-line computing facilities. In atom probe analysis, times of flight are measured over the total flight path of 226 cm to an accuracy of 1 ns, producing an excellent mass resolution. Figure 2, below, presents the time spectrum for the isotopes of tungsten, illustrating the excellent mass resolution possible. The vacuum system consists of twin vacuum chambers, one for sample storage (up to six specimens) and processing (heating, metal deposition, ion beam cleaning and thinning) and the main analysis chamber where the analysis by both atom probe and imaging is carried out.

Actual materials research using the instrument has only just begun. The initial studies will include the determination of the micro-distribution of alloying elements in martensitic and pearlitic steels, nickel-based superalloys, certain semiconducting materials, dislocation-impurity atom interactions, magnetic materials, and surface segregation processes in catalyst materials. This instrument should prove to be a very powerful research tool which will provide experimental data that have been unattainable to date and will greatly increase the basic knowledge of the atomic structure of solids.

Summary

The Department of Metallurgy and Science of Materials at the University of Oxford has many outstanding individuals consistently performing superb research in all phases of materials science. The work that is in progress in

the field of electron microscopy is some of the best in the world. These individuals are young in general, but they are led by experienced men like Hirsch; thus the department is likely to remain a leader in this field for many years to come. If they succeed in building the high-resolution transmission electron microscope with the 0.12-nm resolution, they will have the only instrument capable of resolving individual silicon atoms. The advantage that this might give them in developing semiconducting materials could be tremendous. Combine this with the atom probe for individual atom identification, and they could become world leaders in semiconductor materials research.

The competition between the Oxford group and Thomas' group in Berkeley is healthy and good for everyone involved in the study of materials.

11/2/84

SUPERCONDUCTING MATERIALS, ELECTRODEPOSITION, AND FRACTURE MECHANICS RESEARCH IN NORTHERN ITALY

by Kenneth D. Challenger.

The Politecnico di Milano, the Politecnico di Torino, and the Institute for the Study of Non-Traditional Materials (ITM), Milano, are all performing some high-quality research in materials science. Researchers at these institutions are productive in spite of frequent frustrations caused by government policies on--or indifference to--education and research.

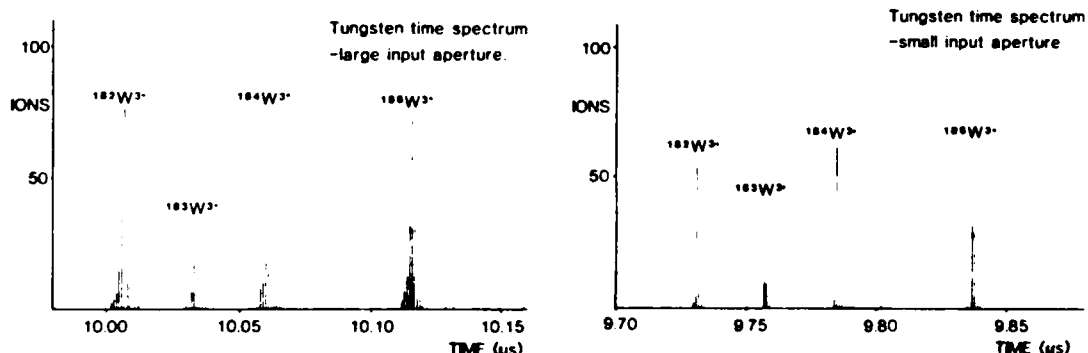


Figure 2. Tungsten time spectra at two acceptance angles ($\theta=32$ mrad and $\theta=20$ mrad); 1-ns timing channels (from G.D.W. Smith et al., "The FIM100--Performance of a Commercial Atom Probe System," paper presented at the 31st IFES, Paris, France, 1984).

ITM

ITM is the only materials research facility that is owned and operated by Italy's National Research Council (CNR). This is somewhat surprising because ITM is very small, with 30 employees, only 10 of whom are graduates; yet CNR operates over 300 laboratories in Italy.

The name of the institute is misleading because they do not study non-traditional materials, but in fact study very traditional subjects: creep and creep-fatigue damage, metallic corrosion, fracture mechanisms, and superconductivity. The researchers have adequate equipment for their work, but the building is old and poorly maintained. They moved into this building as a "temporary measure" 18 years ago, but rumor has it that next year they will move into more comfortable facilities which are more conveniently located to Milano and more suitable for a research facility.

In spite of the poor location they are performing some very interesting and novel research on the metallurgy of superconducting materials.

Dr. E. Olzi has built an excellent facility for electron beam melting, wire processing, and characterizing superconducting materials. At present he is participating in a round robin of European laboratories with the intent of standardizing the methods of characterizing the properties (AC losses and critical current) of superconducting materials. His test facility operates at 4.2°K with fields of 12 tesla. Samples that are 3-cm long are mounted perpendicularly to the magnetic field flux lines. Upon transition to superconductivity (when a voltage drop of 1 mV/cm occurs), a security device stops the current, and the critical current density at the transition is captured in the memory of a digital voltmeter. Most of his work is associated with the development of processing procedures to improve the superconducting characteristics of existing materials and to develop methods to prepare wires of the very brittle superconducting intermetallic phases, such as Nb₃Al and laves phases.

He has developed thermomechanical treatments for Nb-Ti-Ta wires that result in a uniform precipitation of α -titanium. This creates a structure with better fluxoid pinning the critical current for these alloys.

His work on Nb₃Al and the laves phases is focused on developing processing techniques to manufacture wires. Since these materials are very brittle, the wires must be formed from pure Nb and Al, or from pure V, Hf, and Zr for the laves phase wire. He has developed

a process of co-extrusion and drawing of the composite wires; then after winding into the magnetic coil, the wires are heated to between 700 and 800°C for reaction and the formation of the intermetallic phase. He has some very clever ideas that may help solve this difficult problem of processing these intermetallic phases. If he is successful, the payoff will be great because the V₂(Hf,Zr) laves phase has a critical field of 26 tesla compared to about 15 tesla for Nb-Ti-Fa alloys, and its properties are not as sensitive to irradiation damage as the Nb-Ti alloys.

Politecnico di Milano

This is the largest engineering college in Italy. The materials science program is part of the Department of Applied Chemistry. This department has about 40 faculty; about 18 are active in materials-related areas. The research, like ITM's, is supported primarily by CNR, with some additional support from private and nationalized industrial firms. Research on electrochemistry, physical chemistry, and metallurgy is pursued in the department.

My main purpose in visiting the department was to meet Professor Pietro Cavallotti. ONR, London, Liaison Scientist J. Perkins visited Cavallotti in 1979 and found his work to be outstanding (see ESN 34-1:18-20[1980]). He was educated as an electrochemist, but much of his research has been on materials-related topics. A few of his current projects are described below.

One very important aspect of characterizing powders (for use as catalysts, or in powder metallurgy, for example) is their surface area. This is particularly difficult for powders with large surface heterogeneities. The most common method for characterizing the surface properties of these materials is to use physical absorption data to mathematically determine the parameters of a physisorption isotherm. Cavallotti has developed an isotherm that appears to expand the applicable pressure range of this method to much lower pressures and is applicable for sub-monolayer to multilayer coverage.

This isotherm adequately describes the physical absorption data of many different systems: TiO₂ with Ar, N₂, and O₂; MgO with Ar and N₂; hydroxylated SiO₂ with Ar and N₂; nonporous SiO₂ with Ar and N₂; δ -Al₂O₃ with Ar; γ -Al₂O₃ with N₂; graphitized carbon blacks with N₂; C₆H₆ and porous Ag with Ar, Kr, and Xe. The isotherm (and solutions to the isotherm) is an analytical tool for gaining more reliable information about the state and behavior of powder surfaces.

Cavallotti is also studying the kinetics of nitrocarburizing for sintered iron powder parts. The kinetics of nitrocarburizing have been found to differ from solid parts; a study of gaseous nitriding and nitrocarburizing using thermo-gravimetric techniques has shown that the initial kinetics are linear, followed by a second and sometimes a third kinetic reaction which is parabolic. Cavallotti and his coworkers have developed a zone-reaction model to explain these results: chemical reaction and pore diffusion control the kinetics initially, and later diffusion in the product layers becomes the rate-limiting mechanism. The main industrial problem with gaseous nitriding and nitrocarburizing is that the parts expand during the treatment. Cavallotti has developed a new process comprising three steps: oxidation in steam, reduction in hydrogen, and then nitrocarburizing. This overcomes the difficulty of dimensional control by closing the surface pores very early, so that the nitrocarburizing is limited to the region where it is needed--the surface region (for example, for improved wear resistance).

This same research has led to the development of a thermodynamic model for interstitial rich solid solutions. The model is only quasi-chemical, but its parameters have physical significance. This model is capable of explaining the general behavior of iron alloys in carburizing and nitriding reactions.

Yet another program is of considerable interest because of the fundamental aspects of electrodeposition and the commercial applications; this is Cavallotti's research on the electrodeposition of cobalt films for magnetic recording. He and Dr. T. Chen of Xerox Research Laboratories have developed methods to deposit pure Co films with the easy direction of magnetization (c axes of the Co crystallites) perpendicular to the film plane. With proper control of the electrodeposition process, small needle-shaped crystallites can be produced which can support a perpendicular magnetization allowing for a higher density of information storage per unit area.

Cavallotti also has research projects on hot corrosion of nickel-base superalloys; cold sealing of anodized aluminum, preferred orientation crystallization; and the characterization of catalysts used in fuel cells. His output is outstanding.

While at the Politecnico di Milano I also met Professor Roberto Roberti. He is one of the younger faculty members in the department. Most of his research is on fracture mechanisms, performed in

collaboration with Professor Donato Firrao of the Politecnico di Torino. This work is discussed below. Roberti is also collaborating with Milano's Professor Franco Rossitto, a back-up payload specialist for the European Space Agency's Spacelab experiments. Their work is on the role of capillary forces in liquid phase sintering. They are developing models which will predict the ordering of the solid phase in the liquid which occurs during liquid phase sintering as a result of these capillary forces.

Politecnico de Torino

The Politecnico di Torino is the second largest engineering college in Italy. The research in the Materials Science and Chemistry Department is dominated by phase-diagram determinations for oxide systems. This research is led by Professor A. Burdese, dean of engineering, and Professor P. Appendino, chairman of the Materials Science and Chemistry Department. Of the 40 faculty members, about 12 are active in this area. I did not have the opportunity to discuss this work with them, but I had detailed discussions with Professor D. Firrao on his research on surface treatments, fracture mechanisms, and new developments in cast irons. Some of Firrao's interest in surface treatments has resulted in a collaboration with researchers from the phase-diagram-determination group. The phases of the Fe-N-C-X systems, where X is a transition metal, have been carefully identified by x-ray diffraction studies in order to better understand the phases present after nitriding and carburizing surface treatments of steel.

Most of Firrao's research activities focus on the mechanisms of fracture in metallic materials and the development of fracture mechanics concepts for these materials; this is the research performed in collaboration with Roberti from Milano. His work in this field is internationally known as he has collaborated with the late Professor J.W. Spretnak of Ohio State University, and with Dr. J.A. Begley, Westinghouse Research Laboratory.

Recently he has been studying the effect of the notch root radius on the fracture toughness of high-strength steels. He and his coworkers have found that a minimum notch radius exists, below which the fracture toughness of a material becomes independent of the sharpness of the notch. This minimum radius is a function of the amount of crack blunting which precedes crack initiation. This has certain implications in the determination of the

elastic-plastic fracture toughness, J_{IC} , of materials because it means that the tedious process of fatigue precracking of test specimens prior to the measurement of J_{IC} may be eliminated in many instances.

Firrao and Roberti have determined the mechanisms of ductile fracture; this work has led to an understanding of their results on the effect of notch root radius. They have developed a mathematical model for the ductile fracture process which uses their knowledge of the fracture mechanisms to predict the effect of the notch root radius. The important parameters in their model are the strain hardening exponent, inclusion volume fraction and spacing, yield strength, and the plane strain fracture strain (the limiting strain ahead of a crack loaded in plane strain).

This model can be used to predict J_{IC} of a given material by performing a test on a smooth tensile specimen combined with a metallographic examination of the material (this is much easier than performing an elastic-plastic fracture toughness test using the J integral approach). There are many similar models of the ductile fracture process, most of which include these same parameters. Firrao and Roberti are aware of these other models and appear to have incorporated the best points of each into their model.

Firrao also has a research program to study methods to produce grey cast iron with improved fracture resistance. Presently this is done commercially by adding magnesium and nickel to grey cast iron, which causes the graphite to form as spherical nodules instead of flakes. (The graphite flakes are built-in stress concentrators which severely lower the fracture resistance.) Firrao's objective is to achieve a similar effect without the nickel addition and without any heat treatment subsequent to casting. Some success has been achieved by the addition of small amounts of Ti (0.1 percent) and Mg (0.015 percent) to the basic grey cast iron.

Conclusion

The research at all three of these organizations is a good mix of fundamental and applied work. The investigators seem to have very close ties with local industry (see ESN 39-1:16-19 [1984]); thus their fundamental research is focused on topics which will support the long-term needs of these industries. Much of the research seems to follow the lead of scientists and engineers in the US, but there are a few individuals whose work is outstanding.

11/2/84

MECHANICS

DO FAST SHARKS USE RIBPLETS FOR FRICTIONAL DRAG REDUCTION? A PARTIAL ANSWER FROM WEST BERLIN

by Patrick Leehey. Dr. Leehey is the Liaison Scientist for Naval Architecture and Applied Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1985 from the Massachusetts Institute of Technology, where he is a Professor of Mechanical and Ocean Engineering.

Dr. Dietrich W. Bechert of the Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt e.v., Institut für Experimentelle Strömungsmechanik is doing work on frictional drag reduction. Bechert has been working closely with Professor W.E. Reif, a marine biologist at the University of Tübingen. Reif has conducted an extensive study of the structure of the skins of many sharks, both fast and slow. Generally speaking, he has found that the scales of fast sharks have riblets, whereas those of slow sharks do not. As best as is presently understood, these riblets or grooves tend to prevent the formation of quasi-steady longitudinal vortex streaks. It is generally understood that such streaks, when formed, tend to lift from the surface in the form of horseshoe vortices, which then break down to cause a continuing regeneration of the turbulent boundary layer. If this process can be significantly impeded, then the turbulence is reduced in the boundary layer, and consequently the frictional drag is reduced.

Bechert has recently constructed a test apparatus for use in the institute's large subsonic wind tunnel for measuring of the frictional drag on plates on which a variety of drag reduction devices have been installed. The wind tunnel test section is approximately 1.5-m high by 2-m wide and operates with velocities up to 40 m/s. The test rig is very cleverly designed and delicately constructed. It is installed approximately in the middle of the test section and contains a 60-cm-wide by 70-mm-long test plate installed horizontally. This test plate is floated to permit motion in the drag direction, a gap of approximately 0.2 mm is maintained around its periphery. The drag is measured by a linear differential transformer (LDT) in series with a cantilever spring which resists 80 percent of the total drag. Drag in the

range from 10 grams to 170 grams can be measured by this system with an accuracy to 1 percent. Although the test rig is very lightly constructed to avoid tunnel blockage, it is quite precise. A turbulent boundary layer is formed by trips at the forward end of a polished aluminum plate which extends 1-m forward of the test plate. The floating test plate has four legs extended beneath it. Guide wires run from beneath the top of the test plate down to the foot of each leg. Two legs are installed in each of two pairings. The entire test rig is supported on cylinders approximately 1-m long by 1 cm in diameter, wrapped with yarn to prevent vortex shedding. A piston in an oil-filled cylinder is used to damp vibrations from the tunnel blower operation. The system is not self-centering, but deflection of the LDT is sufficiently small that the peripheral gap is maintained without contact.

A first set of tests using riblets for drag reduction has been completed. These are a series of finely spaced grooves in a plate extended in the streamwise direction with a lateral spacing of about 20 viscous lengths between each groove. The depth of a groove does not seem to be critically important nor is the shape of the base of the groove particularly significant. It is important that the ridge of the groove be very sharp. Bechert has measured a drag reduction of 8 percent through the use of riblets of this design.

Bechert then tested an artificial shark skin. This was a cast plastic panel representing the scale structure of a Mako shark. Each scale had longitudinal riblets. The transverse spacing of these riblets was of the same order as in Bechert's groove experiments--i.e., approximately 20 viscous lengths laterally. Unfortunately the experiments to date with the shark skins have not shown drag reduction. This may be because the riblets were not always complete or because consecutive rows of scales were poorly aligned in elevation.

The actual scale structures, however, are more complex than this and involve shallow cavities as well underneath the trailing edges of the scales. Moreover, the scales can flex, somewhat like tabs on an aircraft wing. Thus it is possible that the shark has evolved a far more sophisticated flow control system than that provided by riblets alone.

NEW TECHNIQUES FOR THE STUDY OF HYDRODYNAMIC STABILITY

by Patrick Leehey.

The linearized theory of the stability of incompressible laminar flow amounts to obtaining the eigenvalues and eigensolutions of the Orr-Sommerfeld (O/S) equation. A very large variety of flows can be studied by inserting their mean velocity profile and particular boundary conditions into the O/S problem. Before modern, high-speed digital computation, such solutions were obtained by very painful analyses valid for asymptotically large Reynolds numbers. One of the earliest successful digital approaches was that of Kaplan and Landahl. Basically it employed a shooting technique heading toward the wall from the outer flow. Because of the rapid growth of the inviscid solutions, a continuous process of orthonormalization was required. One of the later techniques was the spectral method of Orszag. These and other numerical analyses were of the finite-difference type.

Recently, finite-element techniques have been applied to this problem, notably at the Istituto di Idraulica of the Università di Roma, Italy. This technique offers a number of advantages over previous methods and has been tested against previous numerical results and a number of experiments by the Rome group.

Numerical Analysis

The principals in the effort at Rome are Professors Paolo Mele, Mario Morganti, and Antonio Di Carlo. Their finite-element solutions have two principal features: first, they use a standard Galerkin procedure based upon Hermite cubics as trial functions; second, for problems with boundary conditions at infinity they use special "bubble" functions over the infinite domains. These functions are matched with common slope at the outer boundaries of the finite element domain to the finite-element test functions. Two principal results evolve from these new techniques. First, it is no longer necessary to use double-precision arithmetic; single-precision arithmetic suffices. This permits solution on modest computers such as the Univac 1100/22 in use at Rome. Second, the bubble-function technique permits the continuous portion of the spectrum of the Orr-Sommerfeld equation to be determined for those problems involving infinite domains. This latter result is quite new.

Experimental Studies

Numerical stability solutions have been obtained for plane Couette flow,

plane Poiseuille flow, plane free jet flow, wall jet flow, and two-dimensional channel flow with a square block on one wall. The last two flows were studied experimentally by the Rome group and compared with numerical analyses. Here too, the methodology is quite unique. First, they have worked in water using laser Doppler anemometry (LDA) in the backscatter mode. Second, they study laminar stability in water flows with 10-percent stream turbulence, a rather audacious step. Third, they carry out spectral-density analyses of the perturbation velocities obtained by the LDA. Their success on the last two counts is, in part, due to the fact that the flows studied are dominated by inviscid (inflectional) instability with low eigenfrequencies.

Both the flow over the top of the square protrusion in the tunnel and the wall jet flow are nearly self-similar. As a result, the O/S stability analyses can be performed and compared directly with the experimental results. It has been found that the most amplified frequencies correspond well with points on Branch II of the spatial stability curve for zones corresponding to the greatest spatial amplification. This is a useful although somewhat incomplete comparison between the theoretical and experimental results. I would have liked to have seen in addition the measurement of the spatial growth rates and the comparison of these with experiments.

Related Work

Other related work includes the experimental study of transition for pulsating pipe flow. Pulsation frequencies from 0.1 to 1.0 Hz are created in a water pipe flow through the use of an oscillation valve followed by a mechanical filter. Dynamic pressure measurements using piezoelectric transducers and dynamic wall-shear-stress measurements with hot film gauges are being used to study the transition of such flows. Professor Bruno Gaddini is calibrating hot film wall-shear-stress gauges in fully developed turbulent pipe flows. The gauges are then being used on three walls of a rectangular channel. The fourth wall has a sediment layer. By measuring the pressure drop along the channel and the wall shear stress on three walls, the shear stress on the sediment layer can be inferred. It should then be possible to determine the minimum shear stress which induces sediment movement.

Conclusion

The Rome Hydraulics Laboratory is definitely not typical. It is too small

for the usual work with models of dams or estuaries. Therefore, more basic work has been undertaken. The results to date and the promise of future results indicate that perhaps it is not a bad thing to have inadequate space. Both computational and measurement techniques have been developed in a very sophisticated way quite out of the ordinary for usual hydraulics work.

11/16/84

SPACE SCIENCE

US AND ITALY DEVELOP SHUTTLE-TETHERED SATELLITE SYSTEM

by Norman F. Ness. Dr. Ness is the Liaison Scientist for Space Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until June 1985 from Goddard Space Flight Center, NASA, where he is Chief, Laboratory for Extraterrestrial Physics.

A unique, bilateral, space-satellite project involves Italy's Piano Spaziale Nazionale of the Consiglio Nazionale delle Ricerche (PNS/CNR) and the US National Aeronautics and Space Administration (NASA). The basic concept of the tethered satellite system (TSS) is due in large part to the pioneering enthusiasm and technical efforts of the late Professor Giuseppe Colombo of Padua, beginning in 1974. A series of three spacecraft (S/C) are to be launched from NASA's space shuttle in 1987-90 but will remain attached to the shuttle by a cable which will have a maximum length of 100 km (Figure 1). With the nominal shuttle orbital altitude of 230 km, this means that the S/C will be able to probe *in situ* the Earth's atmosphere down to an altitude of 130 km. This region of space is usually only probed directly by ground-launched rockets.

The goals of the missions are both technical and scientific. Two primarily different modes of operation are planned, but not by the same S/C. In TSS-1, the cable tether will contain an insulated conducting wire, and the S/C will be deployed above the shuttle altitude to a maximum separation of 20 km. In TSS-2 and -3, a nonconducting tether cable will be employed to effect a maximum separation of 100 km below the shuttle

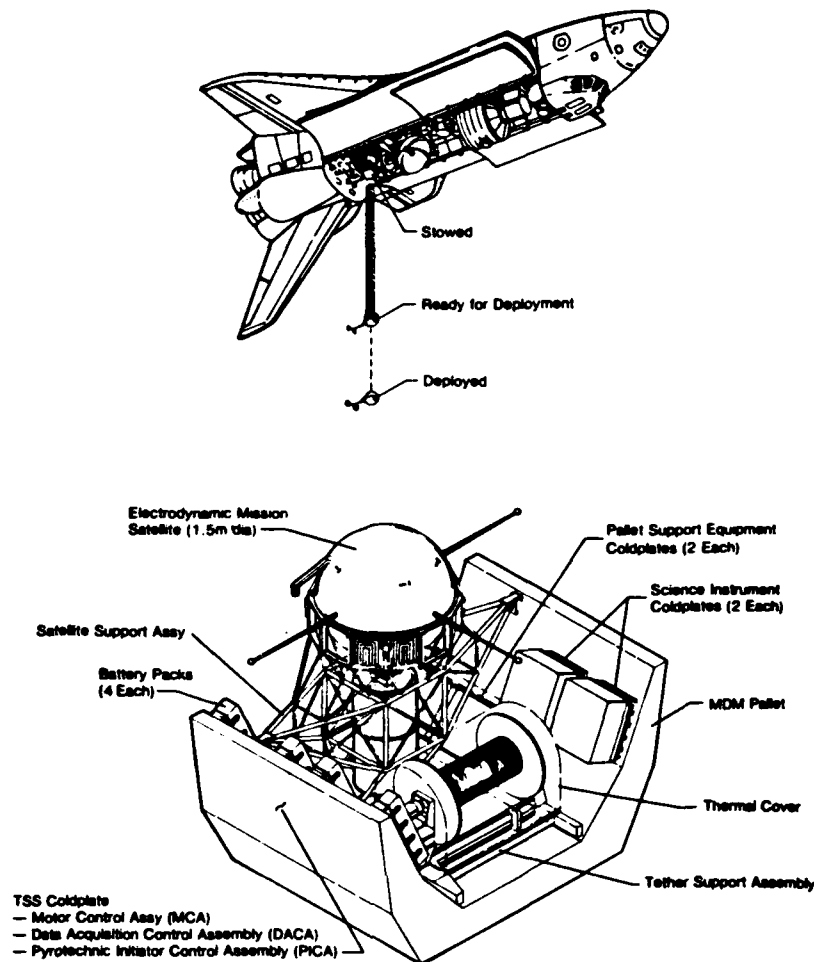


Figure 1. TSS deployer and deployment concept

orbit. This altitude range of 130 to 230 km may be viewed as the critical interface region between the Earth's atmosphere and its magnetosphere.

The primary objectives of the flights are to determine and understand the electrodynamic interaction between the tether/satellite/orbit system and the ambient space plasma; to investigate and understand the dynamical forces acting upon a tethered satellite; and to study local atmospheric, ionospheric, and space plasma properties as well as geodynamical parameters such as the gravitational and geomagnetic fields. The unique feature of the TSS is its low-altitude (130 km) mode. This will be the first time that local measurements at this altitude are possible over a large geographical extent, since previously only vertical rocket probes have studied this region. Were the tether not present, the satellite orbit would rapidly decay due to atmosphere drag.

The initial core payload of instruments consists of a Tether Current-Voltage Controller (TCVC) System for the conducting tether (upward mode) and a three-axis Accelerometer-Gyro System to support studies of TSS satellite dynamics. The TCVC will allow control of the TSS electrical potential and hence the net current that flows between the satellite and the orbiter through the tether as a result of the electromotive forces generated by the motion of the TSS tether cable across the geomagnetic field (a unipolar inductor effect).

The three-axis AGS will provide a highly accurate assessment of dynamic perturbations to the motion of the TSS. These data are required in order to determine the suitability of the TSS as a platform for a variety of investigations of crustal-induced magnetic and gravitational effects. An announcement of opportunity was issued in April 1984, and proposals from European (primarily

Italian) and US investigators were submitted in July 1984. Selection of these additional principal investigator class experiments was expected by late 1984, and a first flight of the TSS is planned in late 1987.

At present, only the first of the three planned TSS missions is currently funded in the NASA shuttle plans. NASA will provide the overall systems engineering and integration for the TSS, including the deployer of the satellite, science instruments, flight-support equipment, and ground-support equipment and software; NASA also will design, fabricate, and test the TSS deployer including the tether materials and associated ground- and flight-support equipment. PSN/CNR will design, fabricate, test, and deliver for integration with the deployer a modular, reusable satellite and associated ground- and flight-support equipment. Both NASA and PSN/CNR will be responsible for assuring the development of instruments selected for flight on the joint missions from proposals submitted by principal investigators from the US and Europe. The Marshall Space Flight Center (MSFC) of NASA has been designated as the project management center for NASA and has contracted with Martin Marietta Aerospace of Denver, Colorado, for full-scale development of the system. PSN/CNR has selected AERITALIA as prime contractor with responsibility for system studies, development of the satellite module, and integration of the scientific payload.

TSS can be visualized as a low-cost recoverable space system, a "satellite on a string" or a "shuttle-borne sky-hook." It will provide an important new facility for conducting space experiments in regions remote from the space shuttle but nonetheless still under the control of the shuttle and its crew.

An interesting aspect of the electrodynamics of the TSS is that its interaction with the Earth's magnetic field is similar to that of Io, a satellite of Jupiter, and the Jovian magnetosphere. The US S/C Voyager I was targeted for a close fly-by of the Io interaction region during encounter in March 1979 and obtained excellent data demonstrating an induced current flow of several million amperes connecting Io to the Jovian magnetosphere.

While currents this large are not expected with TSS, it has been postulated that TSS will be able to run in either a generator or a motor mode, whereby the TSS can provide electrical power to the shuttle system (taken from the orbital motional energy) or in reverse can modify the orbit by using power from the shuttle.

Dr. Nobie Stone of MSFC is the NASA Project Scientist, while Dr. Robert Hudson of NASA Headquarters is the Program Scientist. Further information is available from NASA, Code EPM-20, Washington, DC 20546.

11/6/84

NEWS & NOTES

NORWAY BUILDS WAVE-POWER PLANT

Norway is planning to install what may be the world's first commercial wave-power station. The pilot wave-power plant should be providing light and heat for a local coastal community by next October.

A tiny fjord on an island west of Bergen is being widened and reshaped with concrete walls to form a funnel, or tapered channel. This channel has been carefully designed so that the waves entering from the sea at the wide end maintain their height and increase their speed until they spill into a reservoir at the narrow end of the channel. The wave energy is thus converted to potential energy in the reservoir, which provides a stable water supply for the turbines of a power station.

A company called Norwave is responsible for the project. The company estimates that the power station will produce heat and light at a cost of about 6.5 cents per kilowatt hour.

Norwave hopes that the pilot plant will be the forerunner of a series of wave-power plants--perhaps for island communities in the South Pacific, where waves are plentiful but generator fuel is expensive.

For a discussion of Ireland's research on wave power, see *ESN* 38-1:36-38 (1984).

L.E. Shaffer
11/9/84

NEW JOURNAL FOR MOLECULAR ELECTRONICS

In recent years molecular electronics, a novel approach using both inorganic and organic molecular materials to produce new or improved electronic devices, has gained a prominent position

in microelectronics. Apart from employing more or less familiar electronics and related technologies, molecular electronics draws heavily on the deep physical understanding of sometimes very complicated molecules, including chemical as well as physical properties; sometimes even biological systems may be employed or mimicked.

To facilitate communication between scientists in this truly interdisciplinary area, a new international journal, entitled *Journal of Molecular Electronics*, is being launched in early 1985. This journal will cover topics as diverse as organic and polymeric semiconductors, superconductors, magnetic materials, liquid crystal devices, integrated optics and nonlinear optics, photo effects, photochromism and electrochromism, piezoelectric materials, and related areas.

Research papers will cover fundamental studies concerning the preparation, characterization, and properties of molecular materials, and will also report on actual and potential applications. Both theoretical and experimental contributions will be accepted, but the papers should deal with topics that are directed toward practical devices. Contributions should begin with a general introduction aimed at a very broad readership. Apart from research papers, review articles also will be published.

The journal is produced by John Wiley and Sons, both in the US and in England. The coordinating editor is Dr. R.W. Munn, Department of Chemistry, University of Manchester Institute of Science and Technology, P.O. Box 88, Manchester, M60 1QD, UK. The North American editors are Dr. G. Street, IBM Research Division, 5600 Cottle Road, San Jose, CA 95193, and Professor P.M. Chaikin, Physics Department, University of Pennsylvania, Philadelphia, PA 19104.

Paul Roman
10/29/84

A NEW INTERNATIONAL JOURNAL ON METHODOLOGY IN BEHAVIORAL AND SOCIAL SCIENCES

In 1985 a new journal, *Methodika: An International Journal of Methods in the Behavioral and Social Sciences*, will be published in two issues per year. The journal originates in West Germany but articles will be in English. It will carry original articles on psychological statistics, observational methods, data analysis, psychometrics, mathematical

psychology and sociology, educational statistics and measurement, sociometry, and on methodology in related behavioral and social sciences as well. Book reviews, critical comments, and sources of supply for new procedures and computer programs will also be included. The editor is Dr. J. Krauth, Institute of Psychology, University of Düsseldorf, Universitätsstrasse 1, D-4000 Düsseldorf, West Germany. The publisher is Verlag für Psychologie--Dr. C.J. Hogrefe, Rohnsweg 25, Postfach 3751, D-3400, Göttingen, West Germany. US subscriptions cost \$32 for individuals and \$48 for institutions; to subscribe, write to C.J. Hogrefe, Inc., P.O. Box 51, Lewiston, NY 14092.

Richard E. Snow
11/14/84

HUMAN-COMPUTER INTERACTION RESEARCH-- EAST AND WEST

The number of conferences devoted to reporting and exchanging research and development on human-computer interaction, and particularly the human factors aspect of such systems, has been rapidly increasing of late. The proceedings of some conferences have now been published (see, e.g., Thomas and Schneider, 1984). More are coming. Here are brief notes about several recent and forthcoming meetings in Europe. Their proceedings will also need to be added to library collections on this topic.

INTERACT '84

The first International Federation of Information Processing (IFIP) Conference on Human-Computer Interaction was held from 4 through 7 September 1984 at Imperial College, London. Professor Brian Shackel (Department of Human Sciences, Loughborough University of Technology, Loughborough, Leicestershire LE11 3TU, UK) was chairman of the organizing and program committees. The program was heavy with US and UK participants, but also included contributions from Australia, Bulgaria, Canada, Denmark, Finland, France, Hungary, Japan, The Netherlands, New Zealand, Nigeria, Norway, Sweden, Switzerland, West Germany, and Yugoslavia. Topics discussed included: task analysis and system design; modeling the user; behavioral aspects of text editors; behavioral methodologies--observations and experiments; menu usage; command interfaces and their use; speech IO; advanced

telephone systems; aids for the disabled; adaptive interfaces; novel IO (including shorthand); input devices and comparisons; documentation manuals and on-line help; language design; tools and principles for dialogue design; intelligent software aids; novice and expert comparisons; graphic interaction; computer-aided design; comprehension; terminal and work-place design; design guidelines, methods, and tools; visual and display characteristics; design approaches; training; evaluation problems and methods; electronic mail and computer conferencing; human factors in the system R&D cycle; task allocation; organization and social issues; use of databases and formal representations; user aspects; knowledge based techniques. The proceedings will be published on behalf of IFIP by North-Holland Publishing Company, Amsterdam.

MACINTER

The first network-seminar of the International Union of Psychological Sciences on Man-Computer Interaction Research (MACINTER) was held from 15 through 19 October 1984 at Humboldt University, East Berlin. Professor F. Klix (Department of Psychology, Humboldt University) was the organizer. The papers scheduled for presentation included 19 from East Germany; seven from West Germany; three from the US (although only one US representative appeared--he was Dr. Ernst Rothkopf of Bell Laboratories, Murray Hill, New Jersey, who may be able to give details about some other presentations); two each from Finland, Hungary, Poland, and the USSR; and single papers from Belgium, Bulgaria, Czechoslovakia, France, The Netherlands, Sweden, Switzerland, the UK, and Vietnam. Topics discussed included: the design of human-computer dialogues; knowledge acquisition and learning in human-computer systems; information representation on visual display units; general system design aspects; the child and the computer; knowledge representation and use in human-computer systems; measurement of requirements, mental load, and stress; job organization and allocation of functions between human and computer; and mental representation of computer structure and function. The proceedings will be published by Elsevier Science Publishers (North-Holland), Amsterdam.

IFAC--Analysis, Design, and Evaluation of Man-Machine Systems

The International Federation of Automatic Control (IFAC) will hold its second conference on human-machine systems from 10 through 12 September

1985 in Varese, Italy. For information write to Mr. G. Mancini, c/o Engineering Division, Commission of the European Communities, Joint Research Centre, Ispra Establishment, I-21010 Ispra (Varese), Italy. A call for papers has now been issued. The conference will emphasize recent advances in theory; experimental and analytic research and applications related to human-machine systems; and, particularly, the impact of modern information technology, fifth-generation computers, and expert systems on human-computer interaction. Topics to be addressed include: task analysis of physiological, cognitive, and decision-making tasks; system ergonomics; laboratory, simulator, and field experiments and observations; modeling human performance and joint human-computer systems; interactive characteristics of hardware and software; design methodology; task allocation and sharing; supervisory control; design of interfaces, procedures, and dialogues; pattern recognition; expert and support systems design; the human role; work organization; evaluation of usability, performance, reliability, training, simulators, mental load, and human acceptance and satisfaction. The proceedings will be published by Pergamon Press Limited, Oxford, UK.

Reference

Thomas, J.C., and M.L. Schneider, eds., *Human Factors in Computer Systems* (Norwood, New Jersey: Ablex, 1984).

Richard E. Snow
11/15/84

20th INTERNATIONAL APPLIED MILITARY PSYCHOLOGY SYMPOSIUM

The 20th International Applied Military Psychology Symposium was held in Brussels, Belgium, from 25 through 29 June 1984. It was hosted by the General Personnel Service of the Belgian Armed Forces and the Psychological Research Section of the Belgian Recruiting and Selection Center. The meeting this year enjoyed the largest attendance by countries since the symposium series began in 1963. The sessions included many useful papers and lively discussion. A report summarizing the symposium papers is now available from ONR, London. Copies of reports from previous symposia, at least for recent years, are also still available.

Richard E. Snow
11/15/84

FIRST EUROPEAN CONFERENCE FOR RESEARCH
ON LEARNING AND INSTRUCTION

With support from the Dutch and Belgian governments, and ONR, London, the First European Conference for Research on Learning and Instruction has been organized to take place from 10 through 13 June 1985 at the University of Leuven, Belgium. The aim is to bring together European research in instructional psychology in order to improve communication and promote collaboration within Europe, as well as with US research in this field. The language of the conference will be English. State-of-the-art addresses and specific research reports are to be organized to reflect six main themes: individual differences; discourse processing; problem solving; cognitive-motivational interactions; developmental processes; instructional and social interactions. At the conference, it is expected that a European Association for Research on Learning and Instruction will be founded. For further information on the conference and the proposed association, write to Professor Dr. Erik De Corte, Secretariat of the First European Conference for Research on Learning and Instruction, University of Leuven, Center for Instructional Psychology, Vesaliusstraat 2, B-3000 Leuven, Belgium.

Richard E. Snow
11/15/84

NEW REPORT ON EM ENERGY AND THE NERVOUS
SYSTEM

ONR, London, recently published conference report C-6-84, *Electromagnetic Waves and Neurobehavioral Function: An International Workshop*. The workshop was held in Priorij Corsendonk near Turnhout, Belgium, from 19 through 23 August 1984.

Organized by Drs. Richard H. Lovely, Mary Ellen O'Connor, and Hans Arne-Hansson, the workshop brought together an assortment of researchers, whose task was to dissect the current knowledge base relating to interaction of electromagnetic (EM) energy and the nervous system. The assembled group was unusual in that it was not drawn solely from the community of scientists who are normally concerned with this area of research. Instead, the organizers reached into the ranks of classical neuroscientists, physicists, physiologists, neurotoxicologists, engineers, chronobiologists, and the like to assem-

ble a workshop that would take a fresh, unbiased approach to the subject at hand.

The primary goal of this workshop was to share both common and disparate research objectives, methods, and findings and to identify salient issues which may guide future research. Typically, scientific conferences try to offer definitive answers to old questions through syntheses of data and ideas. Certainly this was one of the goals of the organizers of the workshop. However, they felt it was equally important to generate new questions that are well posed and useful both to the participants and to the scientific community in general.

The workshop was cosponsored by ONR, Arlington, Virginia; ONR, London; and the US Environmental Protection Agency. The papers that were presented will be published by Alan R. Liss, New York, under the title *Electromagnetic Fields and Neurobehavioral Function*. It will be edited by Lovely and O'Connor.

You may order conference report C-6-84 by using the self-addressed mailer inside the back cover of this issue.

Thomas C. Rozzell
11/16/84

THIRD INTERNATIONAL MEETING ON LOW-TEMPERATURE
BIOLOGICAL MICROSCOPY AND ANALYSIS

The Royal Microscopical Society of the UK and The Netherlands Society for Electron Microscopy along with ONR, London, will sponsor the Third International Meeting on Low-Temperature Biological Microscopy and Analysis in Cambridge, UK, to be held from 1 through 4 April 1985. The central theme of the conference will be the use of low temperatures (i.e., below 273°K) in the preparation, examination, and analysis of biological and organic material by light, electron-optical, and other high-energy-beam instrumentation. The two previous meetings, held in 1977 and 1981, resulted in nearly 100 papers published in the *Journal of Microscopy*.

Low-temperature microscopy and analysis is fast becoming a very important tool in cellular and molecular biology. New techniques are being developed which, for the first time, allow fully hydrated biological material to be examined at high resolution (i.e., 1 to 2 nm) in electron-beam instruments.

Vitrified liquid water is now a practical reality and this, together with a better understanding of the problems of radiation damage at 4 to 6°K, now allows for the examination and analysis of biological material in its natural state--albeit at low temperatures.

The conference will be designed with eight major sessions containing four or five invited lectures of 30 minutes each (including discussion). Each of the invited lecturers will be limited to a set number of slides to attempt to ensure adequate time for discussion. In addition to the invited lectures, the organizers will accept contributions from others working in the field. There will also be an evening round-table discussion, exhibits by instrument makers, and a panel discussion on future trends in cryomicroscopy. Those wishing further information about the conference are urged to contact Dr. Patrick Echlin, School of Botany, University of Cambridge, Downing Street, Cambridge CB2 3EA, UK (Telephone: 0223-61414), or Dr. Peter Frederik, Department of Pathology, University of Limburg, P.O. Box 616, 200 MD Maastricht, The Netherlands (Telephone: 043-888472).

Thomas C. Rozzell
11/19/84

IMMUNOCYTOCHEMISTRY MEETING SET FOR JULY

A 4-day meeting on immunocytochemistry will be held concurrently with the International Botanical Microscopy Meeting in York, UK, from 9 through 12 July 1985. The aim of the meeting is to evaluate the newer methods of immunocytochemistry that have been introduced recently, and to survey the fields of activity in which immunocytochemical techniques are proving useful.

There will be scientific sessions covering such topics as tissue handling; embedding; immuno-labeling (fluorescence, metallic, etc.); use of monoclonal antibodies; and the application of immunocytochemistry to both botanical and mammalian systems. There will be a small exhibition of immunocytochemical supplies. Contributed papers are welcome, and inquiries should be directed to the organizers:

Gillian Bullock
Ciba-Geigy Pharmaceuticals
Division
Horsham, W. Sussex RH12 4AB
UK

Julian Beesley
Wellcome Research Labs.
Langley Court
Beckenham, Kent
UK

Thomas C. Rozzell
11/16/84

NUMERICAL METHODS CONFERENCES AT SWANSEA

Two international conferences in numerical methods will be held at Swansea, UK, during July 1985. The Fourth International Conference on Numerical Methods in Laminar and Turbulent Flow will be held from 9 through 12 July. For details, write to Dr. C. Taylor, Department of Civil Engineering, University College, Swansea SA2 8PP, UK.

The following week, 15 through 18 July, the Fourth International Conference on Numerical Methods in Thermal Problems will be held. Dr. R.W. Lewis can be contacted at the above address for information about this conference. For each of the conferences, registration must be made by 1 May to avoid late fees.

C.J. Holland
11/23/84

SYMPOSIUM ON MOLECULAR NEUROBIOLOGY

A symposium entitled "Role of DNA in Brain Activity" will be held in Naples, Italy, from 27 through 29 May 1985 with partial support from ONR, London. The symposium is a satellite meeting of the International Society for Neurochemistry Congress to be held in Riva del Garda, Italy, from 19 through 24 May 1985. The aim of this symposium is to provide an opportunity for the presentation and discussion of the data and concepts pertaining to the emerging field of molecular neurobiology--the applications of the techniques of molecular biology and genetic engineering to basic and applied problems of neurobiology. The speakers, by invitation, will be 30 scientists from Europe, the UK, and the US with expertise in the areas to be covered.

The program will consist of the following topics: (1) chromatin structure, DNA content, and DNA turnover; (2) transcription; (3) genetic engineering; and (4) control of expression.

For conference information, contact: Professor Antonio Guiditta, Conference Chairman, International Laboratory of Genetics and Biophysics, University of Naples, Via G. Marconi 10, I-80125, Naples, Italy.

Claire F. Zomzely-Neurath
11/7/84

SCIENCE NEWSBRIEF FOR NOVEMBER

The following issue of *Science Newsbrief* was published by the ONR, London, Scientific Liaison Division during November. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Science Newsbrief Number

2-15-84

Title

West German Discovery May Reduce Aircraft Drag, by Patrick Leehey.

NOVEMBER MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during November. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB NumberTitle

72-84	The French Nuclear Aircraft Carrier for the 1990s
73-84	French Naval Exhibition Part 1
74-84	French Naval Exhibition Part 2
75-84	French Naval Exhibition Part 3
76-84	The Royal Navy's New Seabed Operations Ship, HMS Challenger
77-84	Norwegian Microwave Remote Sensor for Local Ocean Surfaces
78-84	Norwegian Synthetic Aperture Radar--Update
79-84	European Center for Medium Range Weather Forecasting (ECMWF)--Update
80-84	Modelling Ice-Sheet Surfaces for ERS-1's Radar Altimeter
81-84	Seabed Surveying--University of Bath, UK
82-84	A Proposed Electronic Combat & Reconnaissance (ECR) Variant of the German Tornado
83-84	New Research Ship in UK
84-84	Remotely Operated Vehicle Land

ONRL REPORTS

To request reports, check the boxes on the self-addressed mailer and return it to ONR, London.

C-6-84 *Electromagnetic Waves and Neurobehavioral Function: An International Workshop*, by Thomas C. Rozzell. An international workshop on electromagnetic waves and neurobehavioral function was held in Belgium from 19 through 23 August 1984. The objective was to analyze the current knowledge about the interaction of electromagnetic energy and the nervous system.

- C-7-84 *Fifth Meeting of the European Society for Neurochemistry*, by C.E. Zomzely-Neurath. The fifth meeting of the European Society for Neurochemistry was held in Budapest, Hungary, from 21 through 26 August 1984. The theme for the meeting was "Regulation of Transmitter Function: Basic and Clinical Aspects." This report examines selected topics that not only are of fundamental importance for neurobiologists, but also are being actively pursued by European neuroscientists. The research trends as evidenced by the meeting are: (1) increasing awareness and use of techniques in immunology and molecular biology as aids in elucidation of neurotransmitter regulation; (2) the use of synthetic compounds as agonists or antagonists of neurotransmitter function to obtain more refined neuropharmacological data; and (3) collaborative studies between the various subdisciplines of neurobiology--e.g., pharmacology, physiology, biochemistry, and clinical neurology--to integrate the results obtained into a more comprehensive picture.
- C-8-84 *Fourth International Conference on Robot Vision and Sensory Controls*, by J.F. Blackburn. The Fourth International Conference on Robot Vision and Sensory Controls was held in London from 9 through 11 October 1984. The conference covered the following areas: sensor-based manufacturing, vision systems, sensor-guided welding, three-dimensional sensing, robot guidance and sensory control, nonvision sensing, knowledge-based sensory systems, and advanced vision techniques.
- R-11-84 *The UK Alvey Program in Computer Science: 1984 Update and Assessment*, by J.F. Blackburn. The UK's Alvey program is a 5-year research effort in computer science. This report examines the developments for 1984 in the five areas that make up the program: computer architecture, very large scale integration, software engineering, expert systems and intelligent knowledge-based systems, and man-machine interfaces.

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