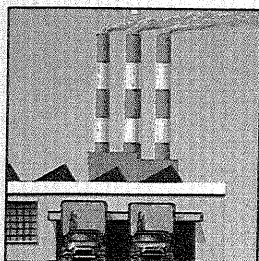


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Global Climatic Change

Richard A. Houghton and George M. Woodwell

Citing historical data on temperature and on atmospheric levels of carbon dioxide and other greenhouse gases, the authors maintain that the world is already in the grip of a warming trend. Unless stringent measures are taken, they contend, rising temperatures will increase sea levels and shift climate zones, causing profound economic and social distress.

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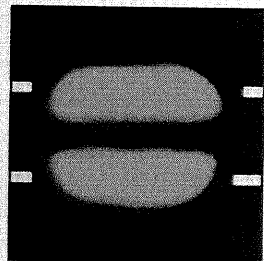


The Turnover of Messenger RNA

Jeffrey Ross

The structure and function of every cell are established by the proteins it synthesizes, and hence by the amount of messenger RNA specifying each protein. The amount of mRNA depends in turn not only on how much mRNA is transcribed from a given gene but also on the rate of turnover, or degradation, of the mRNA. What factors control that rate?

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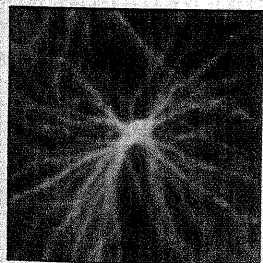


Quantum Interference and the Aharonov-Bohm Effect

Yoseph Imry and Richard A. Webb

Can electrons be influenced by a nearby magnet so well shielded that its force field cannot be detected? The counterintuitive answer is yes: an energy emanation from the magnet known as the potential does indeed affect the electrons' wave function. This quantum-mechanical effect is being brought to bear on the development of new microelectronic devices.

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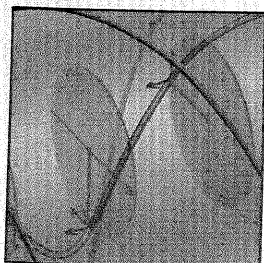


Astrocytes

Harold K. Kimelberg and Michael D. Norenberg

They are brain cells but not neurons. For a long time all that was known about them was that they are star-shaped, beautiful and—unlike neurons—not excitable; they seemed to have a passive supporting role in the brain. Recent work suggests, on the contrary, that they have specific active roles in brain function and development and in causing disease.

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Free-Electron Lasers

Henry P. Freund and Robert K. Parker

FELS can be tuned to any frequency and in theory can be highly efficient. Their potential applications range from research in physics and chemistry through medicine to industrial uses and perhaps strategic defense. Some major new developments in electron accelerators and in "wigglers" suggest that FELS may soon be able to redeem this broad array of promises.

Children of the Garden Island

In 1955, 698 infants on the Hawaiian island of Kauai became participants in a 30-year study that has shown how some individuals triumph over physical disadvantages and deprived childhoods

by Emmy E. Werner

Kauai, the Garden Island, lies at the northwest end of the Hawaiian chain, 100 miles and a half-hour flight from Honolulu. Its 555 square miles encompass mountains, cliffs, canyons, rain forests and sandy beaches washed by pounding surf. The first Polynesians who crossed the Pacific to settle there in the eighth century were charmed by its beauty, as were the generations of sojourners who visited there after Captain James Cook "discovered" the island in 1778.

The 45,000 inhabitants of Kauai are for the most part descendants of immigrants from Southeast Asia and Europe who came to the island to work on the sugar plantations with the hope of finding a better life for their children. Thanks to the islanders' unique spirit of cooperation, my colleagues Jessie M. Bierman and Fern E. French of the University of California at Berkeley, Ruth S. Smith, a clinical psychologist on Kauai, and I have been able to carry out a longitudinal study on Kauai that has lasted for more than three decades. The study has had two principal goals: to assess the long-term consequences of prenatal and perinatal stress and to document the effects of adverse early rearing conditions on children's physical, cognitive and psychosocial development.

The Kauai Longitudinal Study began at a time when the systematic exami-

nation of the development of children exposed to biological and psychosocial risk factors was still a bit of a rarity. Investigators attempted to reconstruct the events that led to physical or psychological problems by studying the history of individuals in whom such problems had already surfaced. This retrospective approach can create the impression that the outcome is inevitable, since it takes into account only the "casualties," not the "survivors." We hoped to avoid that impression by monitoring the development of all the children born in a given period in an entire community.

We began our study in 1954 with an assessment of the reproductive histories of all the women in the community. Altogether 2,203 pregnancies were reported by the women of Kauai in 1954, 1955 and 1956; there were 240 fetal deaths and 1,963 live births. We chose to study the cohort of 698 infants born on Kauai in 1955, and we followed the development of these individuals at one, two, 10, 18 and 31 or 32 years of age. The majority of the individuals in the birth cohort—422 in all—were born without complications, following uneventful pregnancies, and grew up in supportive environments.

But as our study progressed we began to take a special interest in certain "high risk" children who, in spite of exposure to reproductive stress, discordant and impoverished home lives and uneducated, alcoholic or mentally disturbed parents, went on to develop healthy personalities, stable careers and strong interpersonal relations. We decided to try to identify the protective factors that contributed to the resilience of these children.

Finding a community that is willing or able to cooperate in such an effort is not an easy task. We chose Kauai for a number of reasons, not the least of which was the receptivity of the island population to our endeavors. Coverage by medical, pub-

lic-health, educational and social services on the island was comparable to what one would find in communities of similar size on the U.S. mainland at that time. Furthermore, our study would take into account a variety of cultural influences on childbearing and child rearing, since the population of Kauai includes individuals of Japanese, Pilipino, Portuguese, Chinese, Korean and northern European as well as of Hawaiian descent.

We also thought the population's low mobility would make it easier to keep track of the study's participants and their families. The promise of a stable sample proved to be justified. At the time of the two-year follow-up, 96 percent of the living children were still on Kauai and available for study. We were able to find 90 percent of the children who were still alive for the 10-year follow-up, and for the 18-year follow-up we found 88 percent of the cohort.

In order to elicit the cooperation of the island's residents, we needed to get to know them and to introduce our study as well. In doing so we relied on the skills of a number of dedicated professionals from the University of California's Berkeley and Davis campuses, from the University of Hawaii and from the island of Kauai itself. At the beginning of the study five nurses and one social worker, all residents of Kauai, took a census of all households on the island, listing the occupants of each dwelling and recording demographic information, including a reproductive history of all women 12 years old or older. The interviewers asked the women if they were pregnant; if a woman was not, a card with a postage-free envelope was left with the request that she mail it to the Kauai Department of Health as soon as she thought she was pregnant.

Local physicians were asked to submit a monthly list of the women who were coming to them for prenatal care. Community organizers spoke to wom-

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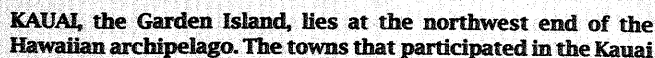
Public-health nurses interviewed the pregnant women who joined our study in each trimester of pregnancy, noting any exposure to physical or emotional trauma. Physicians monitored any complications during the prenatal period, labor, delivery and the neonatal period. Nurses and social workers interviewed the mothers in the postpartum period and when the children were one and 10 years old; the interactions between parents and offspring in the home were also observed. Pediatricians and psychologists independently examined the children at two and 10 years of age, assessing their physical, intellectual and social development and noting any handicaps or behavior problems. Teachers evaluated the children's academic progress and their behavior in the classroom.

court. My collaborators and I also administered a wide range of aptitude, achievement and personality tests in the elementary grades and in high school. Last but not least, we gained the perspectives of the young people themselves by interviewing them at the age of 18 and then again when they were in their early 30's.

Some of the surviving children became "casualties" of a kind in the next two decades of life. One out of every six children (116 children in all) had physical or intellectual handicaps of perinatal or neonatal origin that were diagnosed between birth and the age of two and that required long-term specialized medical, educational or custodial care. About one out of every five children (142 in all) developed serious learning or behavior problems in the first decade of life that required more than six months of remedial work. By the time the children were 10 years old, twice as many children needed some form of mental-health service or remedial education (usually for problems associated with read-

By the age of 18, 15 percent of the young people had delinquency records and 10 percent had mental-health problems requiring either in- or outpatient care. There was some overlap among these groups. By the time they were 10, all 25 of the children with long-term mental-health problems had learning problems as well. Of the 70 children who had mental-health problems at 18, 15 also had a record of repeated delinquencies.

But overall rearing conditions were more powerful determinants of outcome than perinatal trauma. The better the quality of the home environment was, the more competence the children displayed. This could already be seen when the children were just two years old: toddlers who had experienced severe perinatal stress but lived in middle-class homes or in sta-



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ble family settings did nearly as well on developmental tests of sensory-motor and verbal skills as toddlers who had experienced no such stress.

Prenatal and perinatal complications were consistently related to impairment of physical and psychological development at the ages of 10 and 18 only when they were combined with chronic poverty, family discord, parental mental illness or other persistently poor rearing conditions. Children who were raised in middle-class homes, in a stable family environment and by a mother who had finished high school showed few if any lasting effects of reproductive stress later in their lives.

How many children could count on such a favorable environment? A sizable minority could not. We designated 201 individuals—30 percent of the surviving children in this study population—as being high-risk children because they had experienced moderate to severe perinatal stress, grew up in chronic poverty, were reared by parents with no more than eight grades of formal education or lived in a family environment troubled by discord, divorce, parental alcoholism or mental illness. We termed the children “vulnerable” if they encountered four or more such risk factors before their second birthday. And indeed, two-thirds of these children (129 in all) did develop serious learning or behavior problems by the age of 10 or had delinquency records, mental-health problems or pregnancies by the time they were 18.

Yet one out of three of these high-risk children—72 individuals altogether—grew into competent young adults who loved well, worked well and played well. None developed serious learning or behavior problems in childhood or adolescence. As far as we could tell from interviews and from their record in the community, they succeeded in school, managed home and social life well and set realistic educational and vocational goals and expectations for themselves when they finished high school. By the end of their second decade of life they had developed into competent, confident and caring people who expressed a strong desire to take advantage of whatever opportunity came their way to improve themselves.

They were children such as Michael, a boy for whom the odds on paper did not seem very promising. The son of teen-age parents, Michael was born prematurely, weighing four pounds five ounces. He spent his first three

weeks of life in a hospital, separated from his mother. Immediately after his birth his father was sent with the U.S. Army to Southeast Asia, where he remained for two years. By the time Michael was eight years old he had three siblings and his parents were divorced. His mother had deserted the family and had no further contact with her children. His father raised Michael and his siblings with the help of their aging grandparents.

Then there was Mary, born after 20 hours of labor to an overweight mother who had experienced several miscarriages before that pregnancy. Her father was an unskilled farm laborer with four years of formal education. Between Mary's fifth and 10th birthdays her mother was hospitalized several times for repeated bouts of mental illness, after having inflicted both physical and emotional abuse on her daughter.

Surprisingly, by the age of 18 both Michael and Mary were individuals with high self-esteem and sound values who cared about others and were liked by their peers. They were successful in school and looked forward to the future. We looked back at the lives of these two youngsters and the 70 other resilient individuals who had triumphed over their circumstances and compared their behavioral characteristics and the features of their environment with those of the other high-risk youths who developed serious and persistent problems in childhood and adolescence.

We identified a number of protective factors in the families, outside the family circle and within the resilient children themselves that enabled them to resist stress. Some sources of resilience seem to be constitutional: resilient children such as Mary and Michael tend to have characteristics of temperament that elicit positive responses from family members and strangers alike. We noted these same qualities in adulthood. They include a fairly high activity level, a low degree of excitability and distress and a high degree of sociability. Even as infants the resilient individuals were described by their parents as “active,” “affectionate,” “cuddly,” “easygoing” and “even-tempered.” They had no eating or sleeping habits that were distressing to those who took care of them.

The pediatricians and psychologists who examined the resilient children at 20 months noted their alertness and responsiveness, their vigorous play and their tendency to seek out novel

experiences and to ask for help when they needed it. When they entered elementary school, their classroom teachers observed their ability to concentrate on their assignments and noted their problem-solving and reading skills. Although they were not particularly gifted, these children used whatever talents they had effectively. Usually they had a special hobby they could share with a friend. These interests were not narrowly sex-typed; we found that girls and boys alike excelled at such activities as fishing, swimming, horseback riding and hula dancing.

We could also identify environmental factors that contributed to these children's ability to withstand stress. The resilient youngsters tended to come from families having four or fewer children, with a space of two years or more between themselves and the next sibling. In spite of poverty, family discord or parental mental illness, they had the opportunity to establish a close bond with at least one caretaker from whom they received positive attention during the first years of life.

The nurturing might come from substitute parents within the family (such as grandparents, older siblings, aunts or uncles) or from the ranks of regular baby-sitters. As the resilient children grew older they seemed to be particularly adept at recruiting such surrogate parents when a biological parent was unavailable (as in the case of an absent father) or incapacitated (as in the case of a mentally ill mother who was frequently hospitalized).

Maternal employment and the need to take care of younger siblings apparently contributed to the pronounced autonomy and sense of responsibility noted among the resilient girls, particularly in households where the father had died or was permanently absent because of desertion or divorce. Resilient boys, on the other hand, were often firstborn sons who did not have to share their parents' attention with many additional children in the household. They also had some male in the family who could serve as a role model (if not the father, then a grandfather or an uncle). Structure and rules in the household and assigned chores were part of the daily routine for these boys during childhood and adolescence.

Resilient children also seemed to find a great deal of emotional support outside their immediate family. They tended to be well liked by their classmates and had at least one close friend, and usually several. They relied

on an informal network of neighbors, peers and elders for counsel and support in times of crisis and transition. They seem to have made school a home away from home, a refuge from a disordered household. When we interviewed them at 18, many resilient youths mentioned a favorite teacher who had become a role model, friend and confidant and was particularly supportive at times when their own family was beset by discord or threatened with dissolution.

For others, emotional support came from a church group, a youth leader in the YMCA or YWCA or a favorite minister. Participation in extracurricular activities—such as 4-H, the school band or a cheerleading team, which allowed them to be part of a cooperative enterprise—was also an important source of emotional support for those children who succeeded against the odds.

With the help of these support networks, the resilient children developed a sense of meaning in their lives and a belief that they could control their fate. Their experience in effectively coping with and mastering stressful life events built an attitude of hopefulness that contrasted starkly with the feelings of

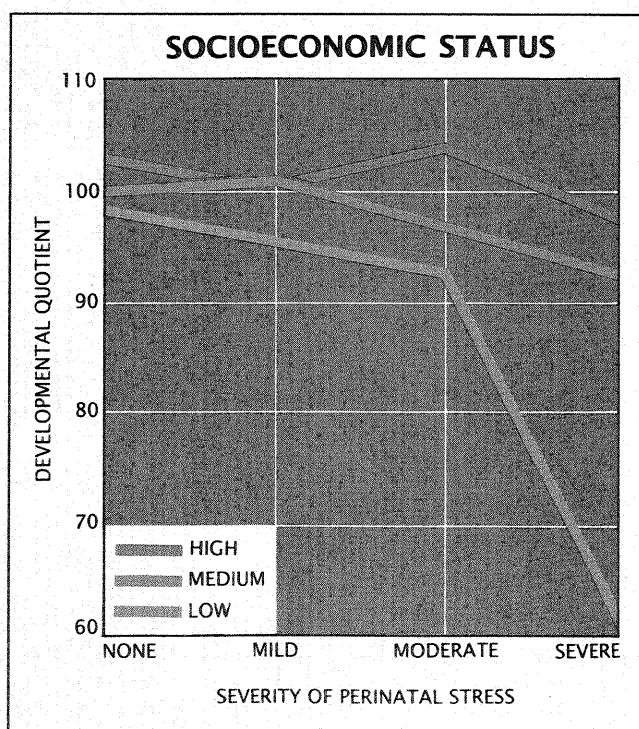
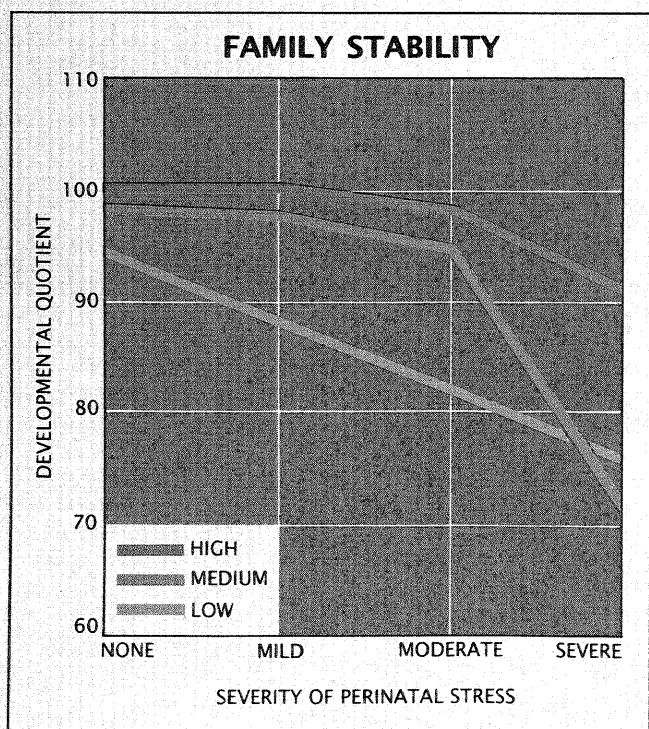
helplessness and futility that were expressed by their troubled peers.

In 1985, 12 years after the 1955 birth cohort had finished high school, we embarked on a search for the members of our study group. We managed to find 545 individuals—80 percent of the cohort—through parents or other relatives, friends, former classmates, local telephone books, city directories and circuit-court, voter-registration and motor-vehicle registration records and marriage certificates filed with the State Department of Health in Honolulu. Most of the young men and women still lived on Kauai, but 10 percent had moved to other islands and 10 percent lived on the mainland; 2 percent had gone abroad.

We found 62 of the 72 young people we had characterized as “resilient” at the age of 18. They had finished high school at the height of the energy crisis and joined the work force during the worst U.S. recession since the Great Depression. Yet these 30-year-old men and women seemed to be handling the demands of adulthood well. Three out of four (46 individuals) had received some college education and were satisfied with their performance in school. All but four worked full time, and three out of four said they were satisfied with their jobs.

Indeed, compared with their low-risk peers from the same cohort, a significantly higher proportion of high-risk resilient individuals described themselves as being happy with their current life circumstances (44 percent versus 10 percent). The resilient men and women did, however, report a significantly higher number of health problems than their peers in low-risk comparison groups (46 percent versus 15 percent). The men’s problems seemed to be brought on by stress: back problems, dizziness and fainting spells, weight gain and ulcers. Women’s health problems were largely related to pregnancy and childbirth. And although 82 percent of the women were married, only 48 percent of the men were. Those who were married had strong commitments to intimacy and sharing with their partners and children. Personal competence and determination, support from a spouse or mate and a strong religious faith were the shared qualities that we found characterized resilient children as adults.

We were also pleasantly surprised to find that many high-risk children who had problems in their teens were able to rebound in their twenties and early thirties. We were able to contact 26 (90 percent) of the teen-age mothers, 56



INFLUENCE OF ENVIRONMENTAL FACTORS such as family stability (*left*) or socioeconomic status (*right*) appears in infancy. The “developmental quotients” derived from tests given at 20 months show that the rearing environment can buffer

or worsen the stress of perinatal complications. Children who had suffered severe perinatal stress but lived in stable, middle-class families scored as well as or better than children in poor, unstable households who had not experienced such stress.

(80 percent) of the individuals with mental-health problems and 74 (75 percent) of the former delinquents who were still alive at the age of 30.

Almost all the teen-age mothers we interviewed were better off in their early thirties than they had been at 18. About 60 percent (16 individuals) had gone on to additional schooling and about 90 percent (24 individuals) were employed. Of the delinquent youths, three-fourths (56 individuals) managed to avoid arrest on reaching adulthood. Only a minority (12 individuals) of the troubled youths were still in need of mental-health services in their early thirties. Among the critical turning points in the lives of these individuals were entry into military service, marriage, parenthood and active participation in a church group. In adulthood, as in their youth, most of these individuals relied on informal rather than formal sources of support: kith and kin rather than mental-health professionals and social-service agencies.

Our findings appear to provide a more hopeful perspective than can be had from reading the extensive literature on "problem" children that come to the attention of therapists, special educators and social-service agencies. Risk factors and stressful environments do not inevitably lead to poor adaptation. It seems clear that, at each stage in an individual's development from birth to maturity, there is a shifting balance between stressful events that heighten vulnerability and protective factors that enhance resilience.

As long as the balance between stressful life events and protective factors is favorable, successful adaptation is possible. When stressful events outweigh the protective factors, however, even the most resilient child can have problems. It may be possible to shift the balance from vulnerability to resilience through intervention, either by decreasing exposure to risk factors or stressful events or by increasing the number of protective factors and sources of support that are available.

It seems clear from our identification of risk and protective factors that some of the most critical determinants of outcome are present when a child is very young. And it is obvious that there are large individual differences among high-risk children in their responses to both negative and positive circumstances in their caregiving environment. The very fact of individual variation among children

who live in adverse conditions suggests the need for greater assistance to some than to others.

If early intervention cannot be extended to every child at risk, priorities must be established for choosing who should receive help. Early-intervention programs need to focus on infants and young children who appear most vulnerable because they lack—permanently or temporarily—some of the essential social bonds that appear to buffer stress. Such children may be survivors of neonatal intensive care, hospitalized children who are separated from their families for extended periods of time, the young offspring of addicted or mentally ill parents, infants and toddlers whose mothers work full time and do not have access to stable child care, the babies of single or teen-age parents who have no other adult in the household and migrant and refugee children without permanent roots in a community.

Assessment and diagnosis, the initial steps in any early intervention, need to focus not only on the risk factors in the lives of the children but also on the protective factors. These include competencies and informal sources of support that already exist and that can be utilized to enlarge a young child's communication and problem-solving skills and to enhance his or her self-esteem. Our research on resilient children has shown that other people in a child's life—grandparents, older siblings, day-care providers or teachers—can play a supportive role if a parent is incapacitated or unavailable. In many situations it might make better sense and be less costly as well to strengthen such available informal ties to kin and community than it would to introduce additional layers of bureaucracy into delivery of services.

Finally, in order for any intervention program to be effective, a young child needs enough consistent nurturing to trust in its availability. The resilient children in our study had at least one person in their lives who accepted them unconditionally, regardless of temperamental idiosyncracies or physical or mental handicaps. All children can be helped to become more resilient if adults in their lives encourage their independence, teach them appropriate communication and self-help skills and model as well as reward acts of helpfulness and caring.

Thanks to the efforts of many people, several community-action and educational programs for high-risk children have been established on Kauai since our study began. Partly as a re-



GRANDPARENTS or other adults can provide a supportive, nurturing role for a child if a parent is absent or becomes ill.

sult of our findings, the legislature of the State of Hawaii has funded special mental-health teams to provide services for troubled children and youths. In addition the State Health Department established the Kauai Children's Services, a coordinated effort to provide services related to child development, disabilities, mental retardation and rehabilitation in a single facility.

The evaluation of such intervention programs can in turn illuminate the process by which a chain of protective factors is forged that affords vulnerable children an escape from adversity. The life stories of the resilient individuals on the Garden Island have taught us that competence, confidence and caring can flourish even under adverse circumstances if young children encounter people in their lives who provide them with a secure basis for the development of trust, autonomy and initiative.

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