Mind/Body Link

Numerous experiments have revealed that our moods, including stress, and our social contacts have an immediate impact on the level of activity of our immune system, and hence our ability to counteract germs.

In the third stage of medicine, one of the frontiers of research will be to explore this link using the tools of molecular biology. The mind/body link, sometimes viewed by traditional medicine as bordering on quackery, will soon reveal its secrets to molecular medicine, which will be able to explore *how* the mind affects the immune system, and vice versa, at the cellular and molecular level. In a sense, we are going full circle on the mind/body link, except our understanding is at a much higher level.

Historically, one frustrating problem with exploring the mind/body link has been the reliance on anecdotal data, which is notoriously subject to extraneous effects, such as the placebo effect, the power of suggestion, and subjective judgments. Without careful experiments, control groups, and meticulous records, it becomes nearly impossible to verify the first-person accounts of remarkable cures and remissions.

Within the last few years, however, there has been a flood of solid new experiments and analyses which point to the existence of this mind/body link. In 1996, a definitive study done at the Johns Hopkins School of Hygiene and Public Health showed a link between heart attacks and depression. Doctors followed 1,551 people for over thirteen years and found that those who were depressed were four times as likely to have a heart attack. In 1993, a landmark study of 752 men analyzed over a seven-year period in Göteborg, Sweden, showed that men who exhibited unusual amounts of stress in their lives died at a rate three times greater than those who were calm, showing a direct link between one's longevity and one's emotional state. High levels of stress were, in fact, better predictors of one's death rate than high blood pressure, cholesterol, or triglyceride levels.

But perhaps more interesting was the finding that for people who led a full social life, with rich interactions with friends, wives, and family, there was no relation between one's life expectancy and one's level of stress. This indicated that social contact helped to assuage the effects of stress on the body. Social isolation, in fact, has been shown to result in alarmingly high death rates.

In 1991, scientists at Carnegie-Mellon University demonstrated how stress can suppress the immune system's response to colds. By deliberately exposing students to cold viruses, they found that among students

with stress, 47 percent came down with colds, compared with only 27 percent of those without stress.

By examining a subject's blood several times a day, one can in fact find a direct correlation between white blood cell activity and levels of stress. Our immune system was shown to be, in a sense, a barometer to our emotional state.

In an important paper in 1993, scientists at Yale University compiled an extensive list of mind/body research, including the harmful effects of stress on diabetes, heart disease, metastasis of cancer, asthma attacks, and bowel disease. Stress even adversely affected the nervous system itself, causing damage to the hippocampus and hence to our memory.

Other studies done recently strengthen the link between stress and other diseases:

- flare-ups in herpes due to stress
- incidence of colon cancer and stress
- incidence of heart disease and hopelessness
- surviving bypass heart surgery and optimism
- surviving second heart attacks and anger
- heart attack rate and depression
- survival rates from breast cancer and participation in support groups

The list of experimental and epidemiological results is quite extensive and has survived peer review in established medical journals.

One of the tasks of twenty-first-century medical science will be to flesh out precisely how this mind/body link operates at the molecular level. On the one hand, there is the well-established relationship between our emotions and our endocrine system. When faced with a life-threatening emergency, our brain sends electrical signals to our glands to emit adrenaline, noradrenaline, and cortisol, which then circulate in our blood and prepare the body for the "flight or fight" response. The brain also signals the glands to produce natural opiates like beta-endorphin and enkephalin to prepare for possible pain. The flooding of our body with these powerful hormones suppresses our immune system (perhaps an ancient evolutionary response to conserve our resources in an emergency).

In 1996, scientists at the National Institute of Mental Health did a careful study of the effect of depression in women (the average age of the women was forty-one). They found that depressed women suffered from 6.5 to 14 percent lower bone density. They also found that these women had higher levels of the hormone cortisol, which can cause bone loss. In a third of the women studied, the loss of bone was so severe that it matched the level of bone loss usually seen after menopause. One theory is that

depression triggers the release of cortisol, which in turn accelerates the loss of bone.

Others believe that there may be a three-way linkage among our immune system, our endocrine system, and our nervous system, which communicate with each other via peptides that travel through the blood, providing a constant feedback among all three, using the blood as its communication system.

These novel discoveries, most of them made within the past five years, may affect how medicine is practiced in the next century. In the future, doctors may take a more comprehensive look at our lifestyles and emotional states, analyzing whether we have social support networks, engage in regular exercise and relaxation (e.g., yoga, meditation, vacations), and have ways to vent our anger and stress. Molecular medicine will force doctors to view the body as a complex web of interacting systems.

Imaging Devices in the Twenty-first Century

Molecular medicine will also be aided by new advances in quantum physics, paving the way for a new generation of imaging devices, including new types of MRI, CAT, and PET scans. Already, these devices have opened up entirely new areas of medicine, allowing us for the first time to view the living brain as it thinks and the inside of the body as it functions. In the twenty-first century, a new generation of these imaging devices will give us the unprecedented ability to see fine details of the living body, such as clogged arteries, microscopic tumors, etc., that up to now have eluded scientists.

Each of these devices originates in a principle in quantum physics. (*CAT scans* use multiple X-ray photographs to create cross sections of the living body. These X-rays are shot through the body at different angles. Computers are then used to reassemble these multiple photographs to produce cross-sectional pictures of the body. *PET scans* use radioactive glucose to detect neural activity within the brain. Since brain activity increases the consumption of glucose, the energy source of the brain, scientists can assess brain activity by measuring concentrations of radioactive glucose, which emits an antielectron [a positron] that is easily detected. *MRI machines* make use of the fact that the nucleus of the atom is spinning like a top. When placed in a powerful magnetic field, these spinning nuclei are all aligned with respect to the field. By applying an external high-frequency signal, one can actually flip these nuclei upside down. When the nuclei revert to their original configuration, they emit a small burst of energy, which can then be detected. Since different nuclei emit different signals, one can differentiate between the various atoms found in the body.)

At present, the resolution of these devices is not very great. X-rays are difficult to focus, and the resolution of PET scans is not very good. In the twenty-first century, however, a new variation of MRI imaging, called echoplanar imaging, will provide imaging speeds which are 1,000 times faster than those presently available. These high-resolution machines will be able to take images at 30 frames per second, which is the rate at which television images appear on the screen. The advantage of this speed is that it will enable doctors to freeze images of the body which are blurred by body fluids or by motion. MRI images, for example, presently cannot take accurate picture of fatty deposits in the heart because the deposits are tiny and the heart is constantly in motion and filled with fluid. This new generation of echoplanar imaging will eventually make it possible to take rapid still pictures of the heart in action, enabling doctors to peer into the various arteries and veins to determine the degree of blockage. This, in turn, could help to control the greatest single health hazard in the Western world: heart disease.

X-ray photographs are foggy because X-ray beams are difficult to focus and manipulate. But in 1996 scientists were able to focus an X-ray beam by shooting it through a block of aluminum. X-rays will travel right through aluminum, but will bend slightly in the process. This small deflection can be exploited by having rows of thin holes drilled into the aluminum block. Each hole will bend the original beam a bit, until the entire beam can be focused down to a tiny spot a few millionths of an inch in diameter. Not only is this cheaper and more reliable than previous techniques; it may have widespread application in etching silicon wafers and in improving imaging equipment using X-rays.

Presently, these imaging machines are primarily used once a problem has already occurred, to check for and measure the amount of damage that has been done. In the future, the quantum theory will make possible a new generation of imaging machines which will detect potential problems years to decades before they actually become problems.

But perhaps the most interesting aspect of the future of molecular medicine is that aging itself might prove to be a treatable disease.