The Intensive Care Unit of the Future

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It is the business of the future to be dangerous…. The major advances in civilization are processes that all but wreck the societies in which they occur.

—Alfred North Whitehead

The only way to predict the future is to have power to shape the future.

—Eric Hoffer

Introduction

The ultimate future of critical care medicine is surprisingly easy to predict with certainty. The difference between a healthy person and ill one can be reduced to the difference in the way their atoms are arranged. From a broken bone to a broken strand of DNA, illness is ultimately reducible to how the structures that embody life are configured and interact with each other. Today’s clinicians can only affect events going on in their patients at the molecular level mostly in indirect ways. We have a little specificity, but no precision. We can introduce molecules (drugs) that turn or on or off certain genes, activate certain molecular mechanisms, or derange or shut down others. Antibiotics do this to flora we consider undesirable or out of control in the patient. Steroids and many other drugs signal genes or, like the pressors, more immediately act on cell machinery. We can poison metabolism and disrupt DNA with chemotherapy and radiation, but we lack the ability, at least clinically, to reset the DNA of a neoplastic cell to its healthy state.

On the macroscopic level we can pinch hit for ventilation, renal function, and even circulation, but our ability to repair or replace severely damaged organs is limited to acquiring them from a naturally “engineered” source via transplantation. No laws of physics speak against nanoscale engineering and, in the fullness of time, it is inevitable (providing we and our technological progress both survive) that we will someday build cell and tissue repair devices that act at the molecular level. The nature and capabilities of such nanoscale medicine are already broadly understood. Indeed, we are today in much the same position Leonardo da Vinci was in 500 years ago.¹ Da Vinci was able to envision most mechanical devices we
know of today, but was unable to build them. He designed countless machines with ball bearings — but the hardened steel needed to fabricate durable, pressure-resistant ball bearings was 300 years in the future.

The Day after Tomorrow: Nanomedicine?

In the mid-1980s, the scanning tunneling microscope (STM) was developed, allowing us for the first time to “see” atoms, and much more importantly, to manipulate them with precision. As the 1989 picture in Figure 13-1 illustrates, it became possible for the first time in human history to manipulate atoms with precision. Since that time it has been possible to design, but not yet build, molecular bearings (Fig. 13-2) as well as countless other nanoscale devices (Fig. 13-3).

The logical endpoint of molecular nanotechnology is the construction of cell and tissue repair devices capable of manipulating the atoms comprising living matter with atomic precision. This is the ultimate future of critical care medicine and the end of aging and disease as we currently understand it.

Long before devices such as the one shown in Figure 13-4 are ever fabricated, medicine will have simpler tools acquired by modifying natural structures. As an example, researchers at the Scripps Institute have reengineered the Cowpea mosaic virus (CPMV; a plant virus) by integrating internalin B (a surface protein on bacteria that facilitates entry of the microorganisms into mammalian