

## Cybermedics

Cybernetics is the study of communication and control processes in biological, mechanical, and electronic systems. Control over machines has evolved for centuries, mostly based on the principle of feedback loops. One of the earliest, and simplest of the feedback loops was the *regula*, first described in the 4th century BC. It is the ancestor of the floating valve in a flush toilet. The flow of water in the upper chamber is controlled by a float attached to a lever which opens and closes a valve. When the bowl is full, the float is at the top and the valve is closed. As the bowl empties the float falls, pulling down the lever that opens the valve to let water in until the bowl is full again, and the float rises to the top and closes the valve.

In the early part of the 20th century, engineers in the steel industry had repeatedly tried to develop methods to manufacture sheet metal of uniform thickness. Through painstaking research they discovered the variables that affected the thickness of the sheet metal—temperature, composition of the metal, speed of the rollers and traction and so forth. They reasoned that if they could maintain all the variables at a constant level, the sheet metal would maintain a constant thickness. They were correct in theory; wrong in practice! Each variable affected the other in ways they could not control. If they raised the temperature, traction decreased and vice versa. No matter what they did, the sheet metal came out uneven.

In 1948 Norbert Wiener published his landmark book on cybernetics. It became an overnight best seller. One of the principles it espoused is that you can control the end product of a process without understanding anything at all about causation. When applied to steel, it was fairly simple to devise a feeler gauge that measures the thickness of the sheet metal as it exits the rollers and sends a signal back that regulates traction, the last variable, and that adjusts and maintains uniform thickness. All that research and understanding for naught! All they had to do was adjust the thickness at the end!

But was it for naught? There are lessons to be learned from this simple experiment in cybernetics that apply to the most complex machine of all—the human body. A recent study documented a 23% decrease in mortality in over 2500 high risk cardiac patients treated with an implantable defibrillator. Like the feeler gauge at the end of the steel plating process, the defibrillator, without knowledge of causation, fixes the problem at the end. Similarly, lithotripsy and pubovaginal slings fix the problem at the end.

Not so with statins, though. Statins are medications that lower cholesterol by inhibiting an enzyme—HMG-CoA reductase that results in decreased production of LDL. During the latter half of the 20th century an enormous research effort was undertaken to confirm what many believed, that high cholesterol was a major risk factor for heart disease and that lowering cholesterol would prevent heart attacks. It proved to be much more complicated than that. LDL bad; HDL good. This increased understanding of causation resulted in a new generation of medications—statins that significantly lower the risk of heart disease and cardiac related deaths by about 25%. Understanding the process has also enabled such therapies as alpha adrenergic blockade for prostatic obstruction and antimuscarinics for overactive bladder. These medicines work in many patients, but not, I think, the way we thought they would. The former doesn't relieve obstruction very well and the latter doesn't abolish involuntary detrusor contractions very well. Nevertheless, most patients derive considerable symptomatic improvement. Why? We don't know.

What does all this mean? It means that we don't understand things nearly as well as some think we do. It is intellectually challenging to try to figure out how things work and it makes sense that alpha adrenergic blockade would relieve outlet obstruction, but in most patients it does not and we don't even know whether it is the outlet obstruction that is causing the symptoms in the first place. It means that logic often plays second fiddle to serendipity. It means that even when things seem to make perfectly good sense they may not be true. It makes sense that early diagnosis and treatment of prostate cancer is a good thing, but no one has convincingly demonstrated it yet. Maybe it is not true!

The question is, do we focus our energies on correcting things after the fact; or on understanding cause and effect. The obvious answer is that we should do both, but there is still a lot of room for humility.

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