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Dear Phil,

Good to hear from you.

You ask for dreams of biology. Let me say a few in the inverted form of questions, hopes, aspirations.

What we most need to understand, and most evade in our present preoccupation with reduction, fragmentation and analysis, is the wholeness of living organisms and of their societies, and even sometimes their societies and environments.

So the two major problems in modern biology -- and ancient -- involve what we may call the sociology of cells acting in concert. As in embryonic development: how, through repeated divisions, what starts as a single cell becomes a highly differentiated adult organism, in which all the parts develop and then act consonantly with one another, all as though guided by a master plan. And in the adult, the closely related problems of regeneration and repair: remote parts of the organism, when wounded, knowing when to restart development and differentiation, and when to stop.

Second, the problem of central nervous integration, the working together in harmony of millions and hundreds of millions of nerve cells. There have been few developments in nerve physiology at once as exciting and as misleading as the introduction of the microelectrode techniques that allow us now to study without limit the behavior of single cells in the nervous system. I say misleading now because of any disappointment with what it has told us, but because of a false illusion of progress with the questions we most need to ask. For unlike muscle, or liver, or gland, or digestive cells, in which to a degree what each cell does the organ as a whole does, the central question with nerve cells is not what they do individually but together. The microelectrode approach is as though one tried to figure out a complicated computer progam by putting electrodes on a few single condensers chosen almost at random.

Both these problems seem to call for some kind of biological field -- but field of what? A field that involves an entire organism; but then we encounter problems that involve much more extended fields, large parts of the planet.

Such as the eel migrations. All the eels of the shores of the Atlantic, European and American, come to separate yet overlapping areas of the Sargasso Sea to spawn. They are two species, and having spawned, the adults all die. The larvae find their way back alone. It takes the American larvae about 15 months, the European larvae about 3 years. We have no idea what guides them. I have quoted Niels Bohr, who said of this, "It is just because they do not know where they are going that they always do it perfectly."

Let me say a last thing, that to me is most telling of all.

I have worked all my scientific life on mechanisms of vision. The field is now exploding, and we have learned and are learning a lot. I want to say this: one can put all of that together and extrapolate it endlessly assuming complete success in all our present efforts, and it says nothing of what it means <u>to see</u>. That is as though in another universe that we know no way to approach. Yet embarrassingly central: all that we know and learn, all our science, is rooted in that consciousness of which we know nothing. We know it alone, yet nothing <u>about</u> it. That is of course where mathematics happens too. Could one figure as well if one didn't <u>know</u> that one was figuring? Like a computer? Does a computer know? How could one find that out?

Thanks for making me dream.

As ever,

George Wald

Have is Handy?