On the physiology of "dying"

Contemporary physiology courses and textbooks justly emphasize the great importance of a myriad of negative feedback cycles that produce homeostasis. Courses also touch on issues related to health and disease. This note concerns what is often neglected in the classroom: a consideration of the importance of positive feedback cycles and a physiological basis for what may distinguish health/illness from dying.

It is difficult to precisely delineate the lines of demarcation that separate the states of being conventionally labeled as "health," "illness," "dying," and "death." Nevertheless, "dying" is a state that health professionals and laypersons can often distinguish quite accurately from both health and illness. "Dying" is characterized by the relatively rapid, degenerative collapse of an organismal system (Integr. Physiol. Behav. Sci. 32: 143–148, 1997). This can be contrasted with the stability and constancy (homeostasis) we associate with both "health" and "illness." However, in the "health" and "illness" states there lurk numerous latent positive feedback cycles. Being coupled to the powerful negative feedback cycles that maintain constancy, positive cycles are prevented from pursuing their explosive and destructive course. Negative feedback cycles, however, fade in the "dying" stages of life because particular links in these cycles become impaired (e.g., a decline in vital capacity prevents the lungs from responding to a demand for more oxygen). As the negative cycles decline, positive feedback cycles, previously held in check, rise explosively and drive physiological variables from their normal values toward extremes. This results in the rapid, accelerating disintegration of the organism, a state referred to as "dying," which terminates in death.

As an example, consider a case in which a pneumothorax is inadvertently induced by a medical procedure (N. Engl. J. Med. 280: 1466, 1969). There results a fall in pulmonary ventilation and oxygen supply to the myocardium. Cardiac output is reduced. This reduces pulmonary blood flow and oxygen uptake, further reducing the oxygen supply to the myocardium. A vicious, positive feedback cycle is in effect: a relentless downward spiral in cardiac output and tissue perfusion ensues. Other positive feedback cycles similarly undermine the balance of the organismal system: the patient is dying.

These concepts can help students in the health professions to think in scientific terms about the distinctions between health, illness, dying, and death.

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Multiple benefits of independent investigations as part of a physiology laboratory section

There are many challenges in today's undergraduate teaching environment. We must try to teach students to be the scientists of the future by encouraging them to be independent think-
ers, to be able to analyze data, and to present results in a coherent fashion to their peers. I have tried to meet these challenges in my comparative physiology laboratory by incorporating an independent laboratory exercise. The independent exercise constitutes 50% of the final grade and includes an evaluation of the experimental design (5%), an oral presentation of the results (10%), and a written report (35%) in the format of a scientific paper.

The students are required to give me the topic, general methodology, and hypothesis they will be testing with their independent experiments by midterm so we can discuss the experiments and I have time to collect any materials necessary for the exercise. We discuss the hypothesis and methodology to ensure the hypothesis is valid based on the current state of knowledge and that the experiment should work as designed. The oral reports are fashioned after the 10- to 15-min oral presentations given at scientific meetings; students present relative background information, methodology, results, and the conclusions of the experiment. Each student receives written feedback about his or her presentation from the audience, and all presentations are given during the last class period so that each student is exposed to the same time constraints. The written report uses the format of a research report in the scientific literature with an additional two sections, theoretical discussion and error analysis. The students are given an extensive description of each of the sections found in a research report in their syllabus at the beginning of the semester. The additional sections are a means to reinforce student understanding of the concepts and to force them to analyze their techniques and the validity of their results.

There are several benefits to using this format because the students play an integral role in every step of the scientific method. The extra thought the students put into the design and hypothesis pays dividends in their understanding of the theory behind the exercises. An additional unexpected benefit has come about in the quality of the written reports of the independent investigations. I feel the benefits the students receive from these investigations make any potential problems well worth maintaining the independent investigations as part of the curriculum.

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