Respiratory Control
A Modeling Perspective
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University Laboratory of Physiology at Oxford
"Modeling of a Biological Control System: The Regulation of Breathing"
Organizing Committee
E. R. Carson (London), D. J. C. Cunningham (Oxford), R. Herczynski (Warsaw)
D. J. Murray-Smith (Oxford) and E. S. Petersen (Oxford)

September 1982
University of California Conference Center at Lake Arrowhead
"Modeling and Control of Breathing"
Organizing Committee
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G. D. Swanson (Denver), S. A. Ward (Los Angeles), K. Wasserman (Torrance)
B. J. Whipp (Torrance) and D. M. Wiberg (Los Angeles)

September 1985
Medieval Abbey of Solignac
"Concepts and Formalizations in the Control of Breathing"
Organizing Committee
G. Benchetrit (Grenoble), P. Baconnier (Grenoble) and J. Demongeot (Grenoble)

September 1988
Shadow Cliff Life Center at Grand Lake
"Control of Breathing: A Modeling Perspective"
Organizing Committee
F. S. Grodins (Los Angeles), R. L. Hughson (Waterloo)
G. D. Swanson (Denver) and D. S. Ward (Los Angeles)
The fourth Oxford Conference entitled "Control of Breathing: A Modeling Perspective" was held in September of 1988 at Grand Lake, Colorado. Grand Lake, also called Spirit Lake, was chosen for the fourth meeting so as to continue the meditative atmosphere of the previous meetings and to put the conference on a new higher plane (8,500 feet). The weather, as promised, exhibited its random-like rain showers. The snow report became essential for traveling the 12,000 foot passes to and from Grand Lake. Even the services such as telephone and electricity proved to be uncertain. In all, the overall atmosphere of Spirit Lake contributed to an uninhibited free-style of presentation and interaction.

All of us who attend the Oxford Conferences share a common interest in exploring respiratory control and the regulation of breathing. Modeling has become an adjunct to our exploration process. For us, models are tools that extend our ability to conceptualize just as instruments are tools that extend our ability to measure. And so these meetings attract physicians, physiologists, mathematicians and engineers who are modelers and modelers who are engineers, mathematicians, physiologists and physicians.

Four of these physician-modelers have now passed away. They have been very important mentors for many of us. J. W. Bellville was my Ph.D. dissertation advisor at Stanford who introduced me to the intrigue of respiratory control. G. F. Filley was my colleague at the University of Colorado who enhanced my thinking about respiratory control. E. S. Peterson was my friend at Oxford who helped me appreciate the history of respiratory control. F. S. Grodins was my mentor at the University of Southern California who taught me to model respiratory control.

I first met Fred Grodins while I was a student at Stanford. He sent me a box of IBM cards that allowed us to explore his 1967 model in detail. The model began to teach us at Stanford almost as if Fred was there in person. While at UCLA, I began to interact with Fred more directly. This was a time when he was concerned about the coupling between ventilation
and cardiac output and their joint role in the exercise hyperpnea problem. I was beginning to develop my feedforward/feedback concept (see front cover) as a useful model. Fred began thinking along entirely different lines.

Whereas many of us were searching for the allusive feedforward exercise stimulus, Fred was intrigued with the idea that optimization considerations might yield a controller structure such that an explicit exercise stimulus was not needed. He was particularly concerned with the coupling between ventilation and cardiac output and that the oxygen cost of moving blood via cardiac output was substantially higher than the oxygen cost of moving air via ventilation. Furthermore, he went on to suggest that if enough constraints were applied to the system variables, the system could behave as observed experimentally without an explicit exercise stimulus! This was a remarkable idea at the time and still is.

The legacy of Fred Grodins is a succession of ideas that continue to surface in a variety of forms at these Oxford Conferences. For it was his pioneering work in modeling that took place in the 50’s 60’s and 70’s that set the frame work for our first meeting at Oxford ten years ago. Fred attended each conference until the Grand Lake meeting when his health prevented him from traveling to Colorado.

Dr. Grodins agreed to be the co-editor of this book which represents the proceedings of the Grand Lake meeting. He served on the planning committee with R. L. Hughson, D. S. Ward and myself. R. L. Hughson agreed to step in as an additional co-editor as the need arose.

All of us on the planning committee appreciate the financial support from the Department of Anesthesiology at the University of Colorado Medical School, the Biomedical Simulations Resource at the University of Southern California and Marquest Medical Products of Denver. We also want to thank the Shadow Cliff Life Center at Grand Lake for hosting the meeting and providing facilities. In addition, we appreciate the long hours of devotion of Mary Ann Hammond, my secretary at Denver. She certainly served in every capacity as required to make this meeting a success.

These Oxford Conferences continue the tradition of bringing together international scientists in a unique setting. The product is the scientific exchange resulting in the proceedings. The process of these meetings is not so apparent but equally important. This process depends on remarkable events. R. Herczynski, who was unable to attend the first three meetings, attended this fourth Oxford Conference at Grand Lake. G. F. Filley, who loved the Rocky Mountains, presented his last scientific
paper at Grand Lake. D. J. C. Cunningham, who acted as our historian with respect to the Douglas expedition to the Rocky Mountains, experienced first hand, the altitude effects of Pikes Peak. B. Torrance, who created a marvelous after dinner speech, saluted Mabel Purefoy Fitzgerald.

George David Swanson
Chico, California
November, 1989
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