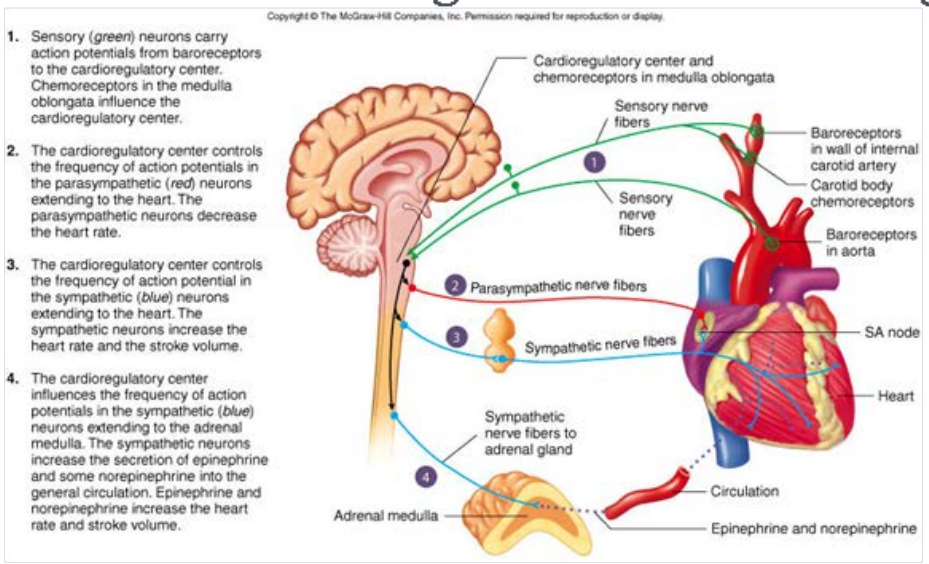
BIOLOGICAL CONTROL SYSTEMS

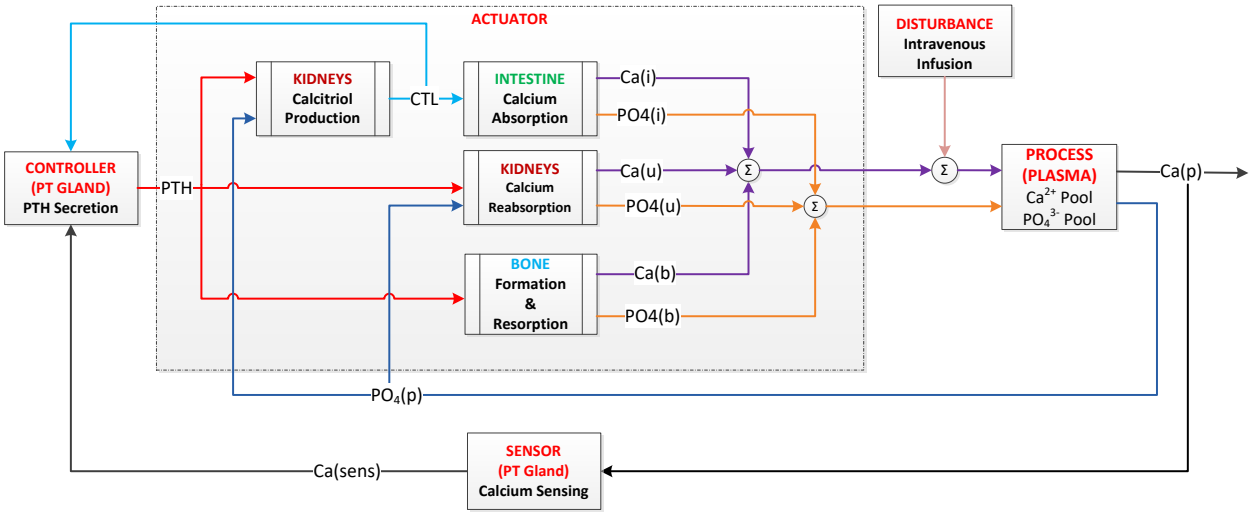
2017 IFAC WORLD CONGRESS WORKSHOP
July 8, 2017
09:00 – 17:30

Instructor: Babatunde A. Ogunnaike

Overall Neural BP Regulation: Process Diagram



The Calcium Regulation Control System Block Diagram



INTRODUCTION

The main objective of the course is to explore the principles and methods by which the mammalian organism maintains stable, efficient and "near-optimal" performance and *homeostasis* in the face of external and internal perturbations. The distinct biological systems responsible for this overall task range from the large scale physiological (nervous, endocrine, immune, circulatory, respiratory, etc) to the cellular (growth and proliferation regulation, DNA damage repair, etc) and the sub-cellular (gene expression, protein synthesis, metabolite regulation, etc). The course presents a control engineering perspective of the function, organization, and coordination of these multi-scale biological systems and the control mechanisms that enable them to carry out their functions effectively.

Presented in modules, the course will cover background material on the physiology of *endogenous* biological control systems (physiological, cellular and molecular control systems) and mathematical analysis of a select few systems.

EXPECTATIONS

Upon completion of the course, the attendee should possess a fundamental understanding of (a) the organization and characteristics of biological control systems (including the differences and similarities between them and engineering control systems), and (b) how physiological variables are controlled across multiple length- and time- scales by these biological control systems. No previous knowledge of physiology is assumed.

COURSE OUTLINE

SESSION AM 1: 9-10 am

MODULE I. Introduction & Overview

Main theme: *Physiologically normal life function is achievable as designed because of CONTROL.*

1. Prelude: Perturbations, Robustness, Feedback, Odds and Ends
2. Engineering of Biological Control Systems: A high level overview of Components, Configurations and Characteristics

Break: 10:00 – 10:15 am

SESSION AM 2 & 3: 10:15-Noon (15 min break at 11:00 am)

MODULE II. Physiological Systems

A. Overview and Control Engineering perspective of General Systems Design & Function

3. Physiological Control Systems: Organization and General Principles
4. The Nervous System
5. The Endocrine System; Nervous-Endocrine synergies; The Immune System
6. The Musculoskeletal and Integumentary Systems
7. The Cardiovascular and Respiratory Systems
8. The Urinary and Digestive Systems
9. The Reproductive Systems

LUNCH BREAK: Noon – 1:00 pm

SESSION PM 1: 1:00-1:45 pm

B. Mathematical Analysis of Physiological Regulation & Control: Specific Examples

10. Pupillary Reflex and Vision
11. Balance
12. Ca^{++} regulation

Break: 1:45 – 2:00 pm

SESSION PM 2: 2:00-2:45 pm

MODULE III. Cellular & Molecular Systems

13. Cellular Physiology: An Overview

Break: 2:45 – 3:00 pm

SESSION PM 3: 3:00-4:00 pm

14. Dynamics of Cellular Regulation
15. Quality Control Systems (Heat Shock response; DNA damage repair)
16. Summary and Conclusions

Break: 4:00 – 4:15 pm

SESSION PM 4: 4:15-5:15 pm

17. Wrap Up: Discussion (Questions & Answers; Future Research Ideas)