SEMINAR ON OPTIMIZATION AND CONTROL, HOMEWORK

Basic Introduction by a Physiologist (Kenner)

1. The allometric function describing the resting cardiac output of different mammals is $CO = k \times M^{0.31}$. Calculate the cardiac output of following animals:

Mammal	Body mass (M, in kg)
Elephant	4000
Horse	700
Human	70
Mouse	0.03
Shrew	0.003

2. The allometric equation describing metabolism (dimension: energy/time) is $Met = k \times M^{\frac{3}{4}}$, with approximately 70 W for man. Calculate the specific metabolism per unit mass of the body for the above mentioned mammals.

3. Remember or look up in the literature: How does blood pressure depend on body mass (M)?

Metabolic control (Schneditz)

4. Calculate the steady state concentrations for glucose and insulin using the Stolwijk & Hardy model and the model parameters given in the handout. Determine the equilibrium concentrations for the normal situation, for 90% insulin resistance, and for 90% ß-cell destruction.

Regulation of Arterial Pressure and Volume Control (Pilgram)

5. Give a short summary of the arterial pressure control over time (see Fig. 1 of the handout).

6. Explain in terms of flow charts (see page 17 of the handout) what may happen if aortic pressure rises or falls in short term and long term regulation (combine Figs. 4, 9, and 10).

Scaling Laws and dimensional analysis in biological transport (Auerbach)

7. Why does wing-length go as $\sqrt{m}$?

8. What is the wingspan of a 10 kg condor?

9. What size wings would we need to fly? (30g sparrows stretch 15 cm).

Control of respiration during rest and exercise (Schneditz)

10. Determine the numerical values (in L min^{-1} $mmHg^{-1}$) for the sensitivity of alveolar ventilation at rest to a change in arterial pCO_2 for a pCO_2 of 30 mmHg and a pCO_2 of 50 mmHg (based on Fig. 6 and on data given elsewhere in the text). Compare the result to the sensitivity (slope) of alveolar ventilation in arterial pO_2.

11. Compare the numerical values (in L min^{-1} $mmHg^{-1}$) for the sensitivity of alveolar ventilation at rest and exercise at an arterial pCO_2 of 45 mmHg and comment the result.

12. When CO_2 is removed from the body by acetate dialysis, why would you expect an increased risk for periodic breathing? Give a quantitative relationship to support your point. Explain the terms "plant gain", "sensitivity", and "loop gain" based on the respiratory control models shown in Figs. 11 and 12 of the handout.