Physiology – It’s Roots

• One of the oldest branches of science
• Starting around 420 B.C.
  – Hippocrates –
    • moved it from theology and religion into its own field
    • Argued that disease was not a handout from angry Gods, but rather from poor diet, environment, and habits
• Called the “father of medicine”
• Founded Hippocratic School of Medicine
• His sons, and son-in-law studied under him
  – Polybus (son-in-law) and Thessalus founded the Dogmatic School of Medicine

Physiology – It’s Roots

• Next big influence was Galen
  – 129-200 (ish) A.D.
  – Became father of modern medicine, studied anatomy* extensively
  • His drawings of mammalian structure were used until 1500’s!
  • Developed the concept that the brain controls the muscles and that there where cranial and peripheral nervous systems

*of monkeys – human dissection not allowed
Physiology – It’s Roots

• Not much happened until…
  – Vesalius (1514 - 1564) was an anatomist and physician
    • Did extensive human dissection
  – Published the premier book on human anatomy *De humani corporis fabrica*
  – Corrected the error of Galen's circulation pattern
    • However held onto the misconception that arteries and veins carry different types of blood
  – Fame led him to become the physician to the Holy Roman Emperor Charles V

• William Harvey (1578 – 1657)
  – Correctly figured out systemic circulation and the properties of blood and its pumping
    • Fixed a century old belief that blood only circulated continuously in the lungs
  – Figured out the function of venous valves
  – First to use quantitative analysis in study of human function
    • Measured how much blood the heart pumped in a day (540 pounds) which then made Galen look silly. . . the liver would have to manufacture 540 pounds of blood each day!
  – Was the personal physician to James I & Charles I

• Claude Bernard (1813 – 1878)
  – The first to establish scientific methodology in medicine
  – Introduced experimental medicine and specifically “blind studies” to ensure objectivity
  – Introduced “Milieu interieur” which was the initial concept of homeostasis
    • “The constancy of the internal environment is the condition for a free and independent life”
    • Furthered in the next century by William Bradford Cannon

• Walter Bradford Cannon (1871 – 1945)
  – Chaired the Department of Physiology at Harvard Medical School
  – Coined the term “fight or flight”
  – Did work with x-rays and different metals to improve x-ray quality of bowels (today’s barium meal is a direct result)
  – Given credit for concept of homeostasis, published it in 1932
Physiology Foundations

• Organization
• Homeostasis & Controls
• Biological Energy
• Structure Function Relationships
• Communication

Homeostasis

• The maintenance of physiological parameters within the body/cell
  – “homeo” = similar or like
  – “stasis” = condition or state
• Provides a teleological answer to questions
• Acts in a mechanistic way
  – Components
  – Process
  – Types

Homeostasis

• Components
  – Receptor
    • Monitors the controlled condition
    • Creates input signal
  – Control center
    • Processes input signal
    • Makes decision
    • Creates output signal
  – Effector
    • Returns controlled condition to normal state in one of two ways

Organizational Hierarchy in Biology
Homeostasis

Process:

- **Functional unit in homeostasis**
  - External change
  - Internal change

- Change results in disruption of homeostasis
- Compensation for change is attempted (feedback processes)
  - Compensation fails
  - Compensation succeeds

- Illness/disease
  - Wellness/health

Homeostasis

- Types of homeostasis maintenance pathways
  - **Negative Feedback Loop Mechanisms**
    - Common
      - Reverse the change in the regulated variable back to normal
    - May be local or long distance
      - Require reflex pathways
  - **Positive Feedback Loop Mechanisms**
    - Rare
      - Enhances the stressor in a cascading effect until stressor is removed, causing regulated variable to return to normal
  - **Feedforward Controls**
    - Aid in homeostatic processes by “anticipating” events, rather than waiting for them to happen and then responding

Homeostasis

- Negative Feedback Control Example: blood Ca\(^{2+}\) levels

  - Regulated variable: blood levels of calcium
    - Normal value: 8.5 – 10.5 mg/dl

  - Change causes: drop in blood levels of Ca\(^{2+}\)

  - PTH secretion is stimulated:
    - ↑Vit D synthesis
    - ↑Ca\(^{2+}\) release from bone
    - ↑Ca\(^{2+}\) reabsorption in kidney

  - Blood Ca\(^{2+}\) levels normalize:
    - ↓Ca\(^{2+}\) uptake in GI tract
    - ↓Ca\(^{2+}\) secretion by kidney
    - ↓Vit D synthesis

  - PTH secretion is inhibited:
    - ↓Ca\(^{2+}\) release from bone
    - ↓Ca\(^{2+}\) reabsorption in kidney

  - Change causes: rise in blood levels of Ca\(^{2+}\)

Homeostasis

- Other Negative Feedback Examples?

  - Blood glucose levels
  - Body temperature maintenance
  - Blood pressure regulation
  - Urine concentration/dilution
  - Ventilation rates
  - Thyroid hormone levels
  - pH controls
  - CO\(_2\) levels
  - GI motility & secretion
  - Cell cycle
Homeostasis

• positive feedback control example: childbirth (parturition)

Regulated variable
female reproductive tract

Change

End of term fetus, uterus contracts,
increases pressure on the cervix

Pressure causes release of oxytocin

Oxytocin causes increased contraction
of the uterus & relaxation of cervix

Process continues until the cervix is dilated enough
and the uterus contractions expel the fetus

Homeostasis

• Other examples of positive feedback loops?

- Lactation
- Some enzyme production
- Hemostasis (blood clotting)

Homeostasis

• Feedforward loops?

Biological Energy

• What is the Biological Energy Currency?
  – Adenosine Triphosphate (ATP)

• Why?

• How is it made?
Structure v Function

• How are the two related?

• Can they be separated?

Communication

• Major theme in physiology
  – Forms
    • Electrical
    • Chemical
  – Between
    • Cell/cells
    • Tissues
    • Organs...

• Communication allows for the integration of physiology!

Integrated Physiology

• What is it?

• How can we grasp it?

• Examples of a integrated physiology illustrations

Integrated Physiology Illustrations
Integrated Physiology Illustrations

Biology 235 Graphic Syllabus

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