

Chapter 1. Introduction to Physiology and Biochemistry

Part 1 | Basics of Physiology

1 Learning Objectives

By the end of this section you will be able to ...

1. **Define “physiology”** and outline its interdisciplinary relationship with physiotherapy.
2. **Explain the concept of homeostasis** and identify the key components of physiological control systems.
3. **Describe negative- and positive-feedback regulation**, including at least three clinical examples relevant to rehabilitation.
4. **Recognise how ageing, disease and exercise modify homeostatic set-points**, shaping assessment and treatment decisions in physiotherapy practice.

2 Definition & Scope of Physiology in Physiotherapy

| Aspect | Explanation | Physiotherapy Touch-point |
|--|--|---|
| Physiology (classic definition) | Scientific study of normal function in living organisms—from molecular to whole-body level | Guides safe exercise dosing, vital-sign monitoring, modality parameters |
| Scope for PTs | <ul style="list-style-type: none"> • Cellular energetics (ATP, pH) • Neuro-muscular transmission • Cardiorespiratory dynamics • Endocrine & metabolic adaptation • Integumentary repair | Exercise prescription, electrotherapy, pulmonary rehab, wound care |
| Why PTs must master physiology | <ol style="list-style-type: none"> 1. Predict systemic response to intervention 2. Detect adverse events early 3. Translate pathology into functional goals | Example: Knowing β -blocker effect on HR use RPE instead of HR training zones |

Key Point: Anatomy tells us **where** and **what**; physiology tells us **how** and **how much**—crucial for evidence-based rehabilitation.

3 Homeostasis - The Core Concept

| Component | Definition | Example in PT Context |
|-------------------------------------|---|--|
| Variable | Physiological parameter kept within limits | Blood glucose during therapeutic exercise |
| Sensor / Receptor | Detects change; sends afferent signal | Pancreatic β -cell senses \uparrow glucose |
| Control (Integrating) Centre | Compares with set-point; plans response | Hypothalamus for temperature; spinal cord for stretch reflex |
| Effector | Executes corrective action | Sweat glands for cooling; quadriceps reflex to prevent knee buckling |
| Negative Feedback | Output negates the original stimulus \rightarrow stability | \uparrow BP \rightarrow baroreflex \downarrow HR/BP (orthostatic training) |
| Positive Feedback | Output amplifies stimulus \rightarrow rapid change, self-limiting | Clot formation after injury; contraction cascade in labour |

Dynamic Nature of Set-points

| Situation | Variable Shift | Clinical Implication |
|---------------------------|--------------------------------------|--|
| Fever | Body temp set-point ↑ 1-2 °C | Active limb movement CI until temp normal |
| Endurance training | Resting HR set-point ↓ (bradycardia) | Lower HR response—use HR reserve not absolute HR for intensity |
| Ageing | Baroreflex sensitivity ↓ | Gradual positional changes to avoid dizziness in older adults |

4 Physiological Regulation Pathways

- Neural (fast, point-to-point)**
Reflex latency ~ 50 ms → stretch reflex governs postural adjustments during balance training.
- Hormonal (slow-to-medium, broadcast)**
Adrenaline surge raises HR & BP during high-intensity interval—factor in rest intervals.
- Autocrine / Paracrine (local)**
Nitric-oxide release by endothelial cells causes local vasodilation → warm-up improves muscle perfusion.
- Intrinsic Rhythms (circadian)**
Cortisol peaks 06 - 09 h; schedule demanding therapy when alertness high for stroke patients.

5 Clinical Examples Linking Homeostasis to Physiotherapy

| PT Scenario | Monitored Variable | Feedback Loop at Work | Intervention Adjusted? |
|-------------------------------------|-----------------------------|--|---|
| Early ambulation post-MI | BP & HR | Baroreflex; sympathetic drive | Keep RPE ≤ 11; sit if SBP drops 20 mm Hg |
| Hydrotherapy for CP child | Core temperature | Thermoregulatory vasodilation & sweating | Limit session to 30 min at 34 °C water |
| Inspiratory muscle training in COPD | PaCO ₂ / pH | Chemoreceptor-driven ↑ ventilation | Titrate load to 30 % P _{Imax} to avoid fatigue |
| Isometric quad set with Valsalva | Intrathoracic pressure / BP | Positive feedback— ↑ BP may overshoot | Coach exhale on effort to break loop |

6 Self-Check Quiz (answers below)

- Define homeostasis in one sentence.
- Which feedback type is involved in lactation?
- Name the primary sensor for arterial O₂ tension and its location.
- During prolonged standing a patient faints. Which homeostatic circuit failed to compensate?
- Why can beta-blockers mask early signs of hypoglycaemia in diabetic patients?

Answers

- Maintenance of a **stable internal environment** by coordinated physiological responses despite external change.
- Positive feedback** via oxytocin release from posterior pituitary.
- Peripheral chemoreceptors** in the **carotid bodies** at the bifurcation of the common carotid artery.
- Baroreceptor reflex** (negative feedback regulating BP).
- They blunt **sympathetic adrenergic symptoms** (tachycardia, tremor) that normally alert the patient to low glucose.

7 • Suggested Learning Activities

| Activity | Purpose |
|--|---|
| Set-point Shift Simulation (computer lab) | Model HR, BP, temp changes during exercise & recovery |
| Homeostasis Role-Play | Students act as sensor, integrator, effector to visualise feedback loops |
| Vitals Monitoring Practicum | Record HR/BP before & after postural change; identify compensatory patterns |

8 Key Take-Home Points

- **Physiology underpins every clinical decision** a physiotherapist makes—from safe mobilisation post-surgery to writing aerobic programmes.
- **Homeostasis is dynamic**, not static; understanding shifting set-points is crucial for individualised care.
- **Feedback mechanisms** can be therapeutically harnessed (training) or inadvertently disrupted (over-stretch, heat, Valsalva)—stay vigilant.

Part 2 | Introduction to Biochemistry

1 Learning Objectives

On completing this section you will be able to ...

1. **Explain why biochemistry matters to physiotherapists** and give three concrete clinical examples.
2. **Recall the core chemical principles**—atomic structure, bonding, water chemistry, pH, buffers, energy coupling—that underpin human physiology.
3. **Describe the four major classes of biomolecules** and relate each to tissue structure or metabolism important in rehabilitation.
4. **Interpret common biochemical data** (e.g., blood glucose, creatine-kinase, lactate) and adjust treatment plans accordingly.

2 Why Biochemistry for Physiotherapists?

| Physiological Process | Biochemical Basis | PT Relevance |
|--------------------------------------|---|---|
| Muscle contraction | ATP hydrolysis by myosin ATPase; Ca ²⁺ binding to troponin | Guides rest intervals in strength programmes; explains fatigue ↓ ATP |
| Bone remodelling | Collagen cross-linking, hydroxy-apatite mineralisation (Ca ²⁺ , PO ₄ ³⁻ , vitamin D) | Weight-bearing exercise ↑ osteoblast activity; nutrition advice on Ca ²⁺ , Vit D |
| Energy supply during exercise | Glycolysis, Krebs cycle, oxidative phosphorylation | HIIT taps anaerobic glycolysis → ↑ lactate; aerobic endurance uses β-oxidation |
| Inflammation & healing | Cytokines, prostaglandins, collagen synthesis (vit C co-factor) | Plan loading around inflammatory vs proliferative phases; advise vit C for tendon repair |
| Nerve conduction | Na ⁺ /K ⁺ ATPase gradients; neurotransmitter synthesis (ACh, GABA) | Electrotherapy parameters & fatigue risk in neuropathies |

Bottom line: **Biochemistry translates cellular events into functional outcomes**—the core of evidence-based rehabilitation.

3 Essential Chemical Principles

| Concept | Key Points | Clinical Link |
|--------------------------------|---|--|
| Atoms & Ions | H, C, N, O = 96 % body mass; Ca ²⁺ , Na ⁺ , K ⁺ , Cl ⁻ crucial ions | Na ⁺ -K ⁺ imbalance alters nerve excitability—watch electrolyte labs before NMES |
| Chemical Bonds | Covalent (strong) in proteins; Ionic in bone salts; H-bonds in DNA & water | Wound collagen cross-link density affects tensile strength; glycosaminoglycan H-bonding retains water in cartilage |
| Water | High heat capacity & solvent of life; 60 % body weight | Hydration status influences thermoregulation during hydrotherapy |
| pH & Buffers | Blood pH 7.35-7.45; bicarbonate buffer + respiratory compensation | High-intensity exercise ↓ pH; cue active recovery and breathing control |
| Concentration / Osmosis | Osmotic pressure drives capillary exchange; albumin maintains oncotic pressure | Edema management—muscle pump & compression garments aid venous/lymph return |
| Energy Transfer | ATP ⇌ ADP + Pi + 7.3 kcal; NAD ⁺ /FAD redox pairs | Creatine supplementation ↑ phospho-creatine buffer → may aid high-load rehab |

4 Macromolecules - Quick Reference

| Class | Monomer | Physiological Role | Rehab Touch-Point |
|----------------------|---|--|---|
| Carbohydrates | Glucose, glycogen | Rapid ATP; cell-surface recognition | Carb timing for glycogen re-synthesis post-exercise |
| Lipids | Fatty acids, triglycerides, phospholipids | Energy store, membrane fluidity | Essential fatty acids modulate inflammation (ω-3 intake) |
| Proteins | 20 amino acids | Enzymes, contractile filaments, carriers | Adequate protein (1.2-1.6 g·kg ⁻¹) for muscle hypertrophy |
| Nucleic Acids | Nucleotides | Genetic code, ATP | Satellite-cell activation in muscle repair depends on DNA transcription |

5 Energy Systems Overview

| System | Location | Duration | Fuel | Key Enzymes | PT Application |
|-----------------------------|----------------------|----------------|----------------------|---------------------------------|--|
| ATP-PCr (alactic) | Cytosol | 0-10 s | Phospho-creatine | Creatine kinase | 1-RM lifts, plyometrics |
| Anaerobic Glycolysis | Cytosol | 10-120 s | Muscle glycogen | Phosphofructokinase | HIIT; monitor lactate |
| Aerobic Oxidative | Mitochondria | >2 min | Glucose, fatty acids | Citrate synthase, ETC complexes | Endurance walking programmes |
| β-oxidation | Mitochondrial matrix | 20 min → hours | FFA from adipose | Acyl-CoA dehydrogenase | Long, low-intensity cardio for obese clients |

6 Clinical Chemistry Markers Every PT Should Know

| Marker | Normal Range | What It Indicates | PT Action Point |
|-----------------------------|------------------------------|--------------------------------|--|
| Fasting glucose | 70-100 mg·dL ⁻¹ | Energy supply; diabetes risk | If < 70 or > 250 mg·dL ⁻¹ postpone vigorous exercise |
| Creatine-Kinase (CK) | ♂ 40-200 U/L ♀ 20-180 U/L | Muscle damage (rhabdomyolysis) | After eccentric session CK may rise; monitor hydration, load progression |
| Lactate (rest) | 0.5-2.0 mmol·L ⁻¹ | Anaerobic metabolism | Use lactate threshold to set endurance intensity |
| pH (arterial) | 7.35-7.45 | Acid-base balance | COPD exacerbation may show pH < 7.30; hold chest PT if unstable |



7 Self-Check Quiz (answers below)

1. Which property of water helps maintain stable core temperature during a 30-minute cycling session?
2. Identify the buffer pair that regulates blood pH and state its Henderson-Hasselbalch equation.
3. Why does a low-carbohydrate diet impair high-intensity exercise performance?
4. Name the enzyme that converts pyruvate to lactate and explain why lactate is not a “waste” product.
5. Give two biochemical reasons muscle protein synthesis is blunted in the elderly.

Answers

1. Water's **high specific heat capacity** absorbs excess heat with minimal temperature rise.
2. **Bicarbonate-carbonic acid buffer**; $\text{pH} = 6.1 + \log \left(\frac{[\text{HCO}_3^-]}{0.03 \times \text{PaCO}_2} \right)$.
3. Glycolysis depends on stored muscle **glycogen**; low carbohydrate means limited substrate → early fatigue.
4. **Lactate dehydrogenase (LDH)**; lactate shuttled to heart/slow muscle & liver (Cori cycle) for ATP or gluconeogenesis.
5. ↓ Anabolic hormone (IGF-1) signalling **and** ↑ chronic inflammation (inflamm-aging) activate proteolysis pathways.

8 Key Take-Home Points

- **Biochemistry explains the “why” behind physiological responses**—energy supply, tissue repair, acid-base balance.
- **Water, ions, pH and ATP** are foundational themes; disturbances show up in vitals and lab values every PT should interpret.
- **Integrating biochemical insight with anatomy and physiology** enables precise, safe rehabilitation programming.