

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.