**HealthIQ AI v5**

**Functional & Technical Design Document**

**1. Vision & USP**

**World’s most advanced personalised biomarker analytics platform.**

* **Mission**: Transform routine blood results into a deep, interconnected health intelligence journey — grounded in clinical science, enriched by AI, delivered through an elite UX.
* **Unique Selling Proposition (USP)**:
  + Every biomarker fully explained in biological and systemic context
  + Canonical-only downstream enforcement — no leaks of raw/non-canonical names
  + Network-based interpretation through **clusters** and **composite signatures**
  + Narrative, visual, and interactive insights — far beyond “PDF-like” reports
  + Clinically credible, evidence-based thresholds with confidence intervals

**2. Functional Scope**

**User Workflow**

1. **Data Ingestion**
   * Upload PDF, CSV, or manual entry of blood results
   * Complete structured lifestyle questionnaire
   * Metadata: age, sex, demographics
2. **Canonical Normalisation**
   * Map non-canonical names to canonical IDs via BiomarkerAliasResolver
   * Derived values auto-calculated (TG:HDL, HOMA-IR, etc.)
3. **Scoring & Cluster Analysis**
   * Each biomarker scored against evidence-based ranges
   * Cluster engines detect patterns (e.g. *Silent Inflammation Load*)
   * Composite signatures evaluated (e.g. *Longevity Resilience Index*)
4. **Insight Generation**
   * Insight orchestrator aggregates biomarker + cluster outputs
   * Gemini/Narrative AI produces personalised explanation
   * Recommendations surfaced with evidence and confidence levels
5. **Frontend Experience**
   * Real-time progress pipeline (Upload → Normalise → Score → Cluster → Insights)
   * Interactive biomarker cards, cluster radar, trend charts
   * Narrative cards with trust indicators, confidence, and lineage
   * Exportable reports and provider/family sharing

**3. Technical Architecture**

**Backend (Python, FastAPI)**

* **Data Models**: Pydantic immutable models (BiomarkerValue, BiomarkerPanel, UserContext)
* **Context Layer**: AnalysisContext with strict validation (frozen objects)
* **Canonical Enforcement**: \_assert\_canonical\_only() at orchestrator boundary
* **Scoring Engine**:
  + Evidence-based thresholds (with ranges + confidence intervals)
  + Derived ratios and composite signatures
* **Insight Engine**:
  + BaseInsight contract → per-domain insights (Metabolic Age, Heart, Detox, Inflammation)
  + CompositeSignature layer for multi-biomarker USP patterns
* **Narrative AI**: Structured JSON → Gemini prompt → personalised summary
* **Database**: Supabase (Postgres) for user data, biomarker refs, signatures
* **APIs**: FastAPI with OpenAPI docs, <200ms target response

**Frontend (Next.js + React + Tailwind + TypeScript)**

* **Component Domains**:
  + Analysis/ → pipeline progress, real-time normalisation visual
  + Visualization/ → interactive panels, cluster radar, trends
  + Narrative/ → insight cards, recommendations, progress tracking
  + Collaboration/ → shareable reports, provider/family views
* **State Management**: React Query + Zustand
* **Mobile-First UX**: progressive disclosure, offline caching, accessibility config
* **Visualisation**:
  + react-gauge-chart for biomarker dials
  + D3.js/Chart.js for radar + trend graphs
  + Cross-correlation heatmaps

**Cross-Cutting Services**

* Notifications (email, in-app)
* Storage (Supabase buckets for uploads)
* Logging/Monitoring (Prometheus/Grafana)
* Security (JWT auth, RBAC for providers)

**4. Sprint Roadmap**

**Sprint 0: Foundation Setup**

* Repo setup (backend/, frontend/, docs/)
* CI/CD pipeline (tests + lint)
* Supabase/DB schema migration
* Dev tools: Cursor, Pre-commit hooks, mypy, pytest baseline

**Sprint 1: Technical Foundation**

* Implement canonical-only context architecture (as per Claude’s doc )
* Replace legacy contexts with AnalysisContext
* 95%+ coverage on context pipeline
* Load + performance baseline established

**Sprint 2: Clinical Depth**

* Audit and update biomarker thresholds with evidence refs
* Add 15–20 advanced biomarkers (hormones, advanced lipids, micronutrients)
* Implement 3 new health domains (Hormonal Health, Micronutrients, Cardiovascular)
* Clinical advisory board recruited

**Sprint 3: UX Excellence**

* Build frontend progress pipeline, biomarker cards, cluster radar
* API standardisation with error handling
* Mobile optimisation and progressive loading
* Launch personalised recommendation engine (frontend)

**Sprint 4: Intelligence Differentiation**

* Implement composite signatures (Longevity, Fatigue, Silent Inflammation, Metabolic Instability, Detox)
* Build correlation engine + predictive analytics
* Deploy unique Health Intelligence Score
* Integrate AI Health Coach (Gemini-powered)

**5. USP Integration: Why This Architecture Wins**

* **Canonical Boundary Enforcement**: Prevents the technical debt problems of v4
* **Cluster & Signature Layer**: Encodes HealthIQ AI’s unique systemic interpretation
* **Immutable Contexts**: Reliable, type-safe foundation (no silent state bugs)
* **Narrative Layer**: Gemini only interprets structured canonical outputs → no hallucinations
* **Elite UX**: Progress transparency + interactive exploration builds user trust and engagement
* **Clinical Credibility**: Evidence-backed thresholds + advisory board oversight

**6. Success Criteria**

* **Technical**:
  + 99.9% uptime
  + <200ms API response
  + 95% test coverage
* **Clinical**:
  + 75+ biomarkers
  + 12+ health domains
  + Advisory board + published validation
* **UX**:
  + 80% user return within 30 days
  + 4.5/5 satisfaction
  + 25% trial → paid conversion
* **Market**:
  + Top 3 awareness in health insights
  + 100k active users in 12 months

✅ This document is standalone — it links your **tech stack directly to your USP** (clusters + composite signatures as the moat). It tells devs **what to build (pipeline, canonical boundary, clusters, UX)**, **how to build (Pydantic models, Next.js state, Supabase)**, and **when to build (Sprint roadmap)**.

Would you like me to now **package this into a polished PDF functional + technical design spec** so you can circulate it with the team as an official blueprint?