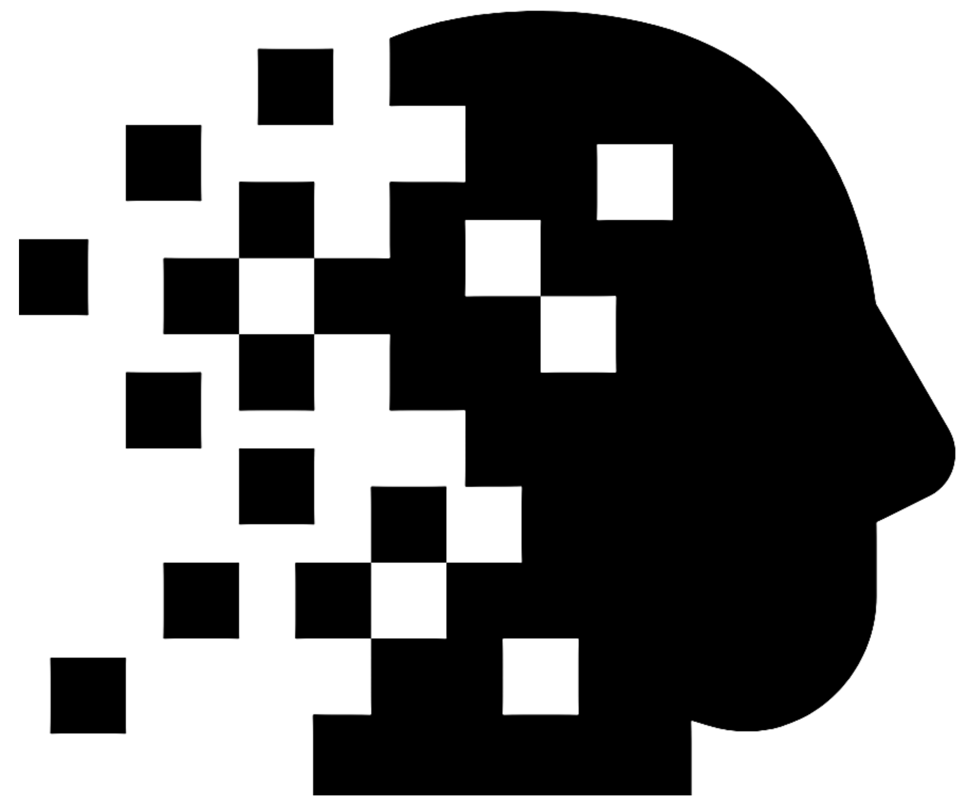

How biomarkers and artificial intelligence (AI) are innovating personalized nutrition: the importance of a robust computational infrastructure

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(i) Fundamentals: Role of biomarkers in personalized nutrition

Personalized nutrition holds the promise of revolutionizing health and wellness through **advancements** in **biomarkers** and **AI**. **Biomarkers** offer accurate assessments of nutritional status by **detecting molecular and biochemical changes** in the body that indicate the correlation to **dietary nutrient intake** or **metabolism**. Meanwhile, AI analyzes extensive datasets encompassing **genetic profiles, dietary habits, and health data to generate tailored recommendations.** This combination accounts for individual genetic, environmental, and behavioral factors, enhancing data accuracy and surpassing the limitations of population-based studies.

Despite developments in nutritional research facilitated by **omics and data technologies,** establishing a **robust computational infrastructure** for personalized nutrition remains critical. This infrastructure must address challenges in dietary intake databases by capturing intricate patterns and systematically translating food's chemical components into energy and nutrients. A **bionformatics framework** has the potential to foster **customized, standardized**, and **annotated nutritional databases**, thereby advancing dietary monitoring and management capabilities.

Additionally, **AI systems can iteratively train and tailor based on feedback**. This allows them to fine-tune the diet plan for better results over time. However, their implementation demands careful and ethical professional oversight and is expected to improve the accuracy, reliability, and accessibility of personalized guidance in the future. **This review shows the importance of a robust computational infrastructure to improve the quality of nutritional health.**

(ii) AI in personalized nutrition: biomarker focus

Data collection: Genomics, **biomarkers** (e.g., blood nutrient levels, enzyme activity), healthcare records, and wearable devices.

Customized plans: AI analyzes data to create dietary suggestions aligned with health goals, preferences, and nutrient needs.

Biomarker integration:
- Blood nutrient levels (e.g., vitamin D, folate)
- Glucose and insulin levels
- Inflammatory biomarkers (e.g., CRP)
- Gene expression changes,

assesses nutrient uptake, deficiency risk, and metabolic responses.

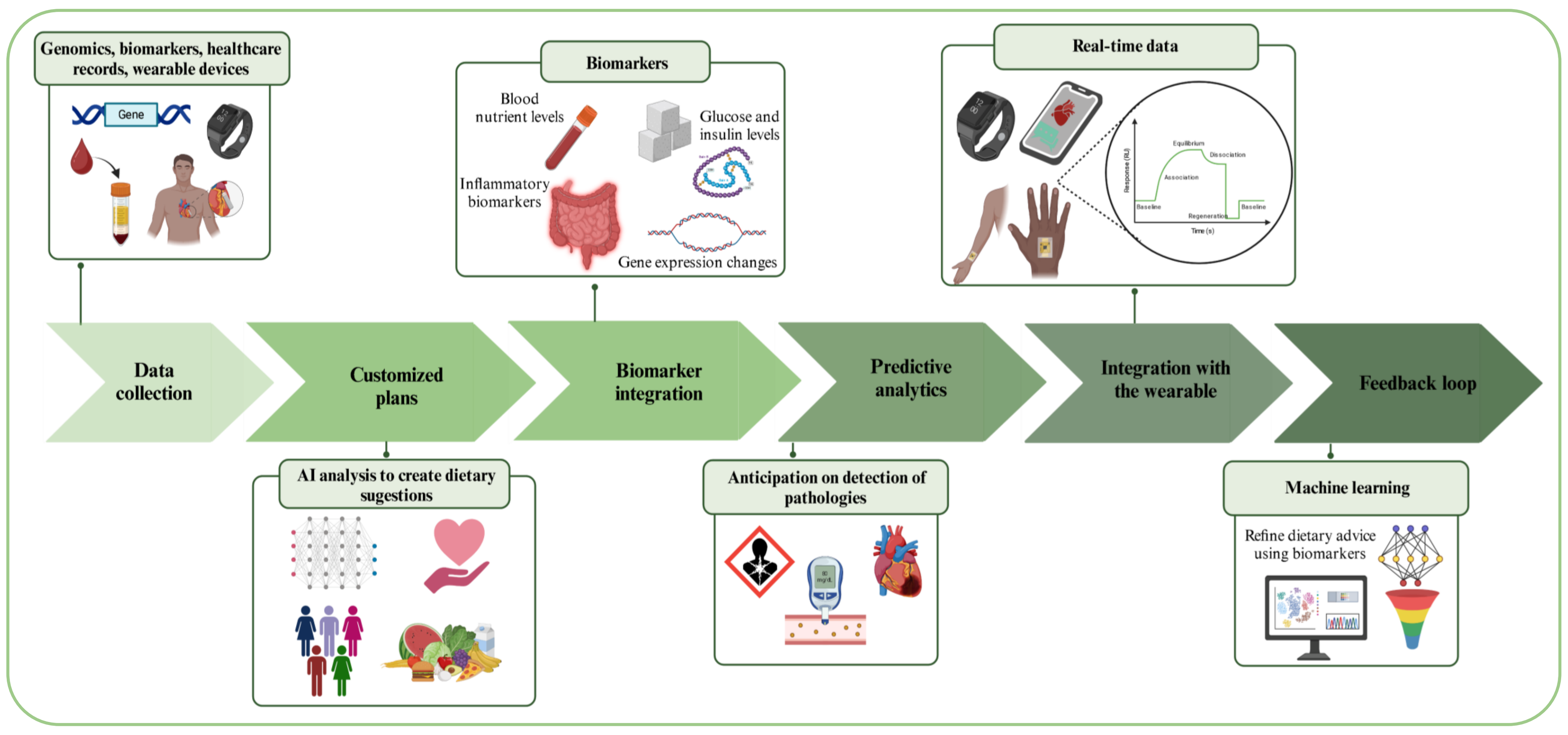
Predictive analytics: Anticipates health conditions, supports diabetes and cardiovascular disease management.

Integration with wearable: Real-time data from trackers adjusts diets based on sleep, activity, and other health metrics.

Feedback loop: Machine learning refines dietary advice using **biomarker** feedback.

(iii) Machine learning algorithms for personalized nutrition

The diagram below represents **personalized health** and **diet optimization** through genomics, biomarkers, and wearable device data. It combines **real-time health monitoring** with **AI-driven dietary** suggestions and **predictive analytics**



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(iv)

to facilitate early **detection of pathology** and dynamically improve recommendations. A feedback loop, powered by machine learning, continuously improves the system using biomarker insights and user outcomes.

(v) Building a robust computing infrastructure

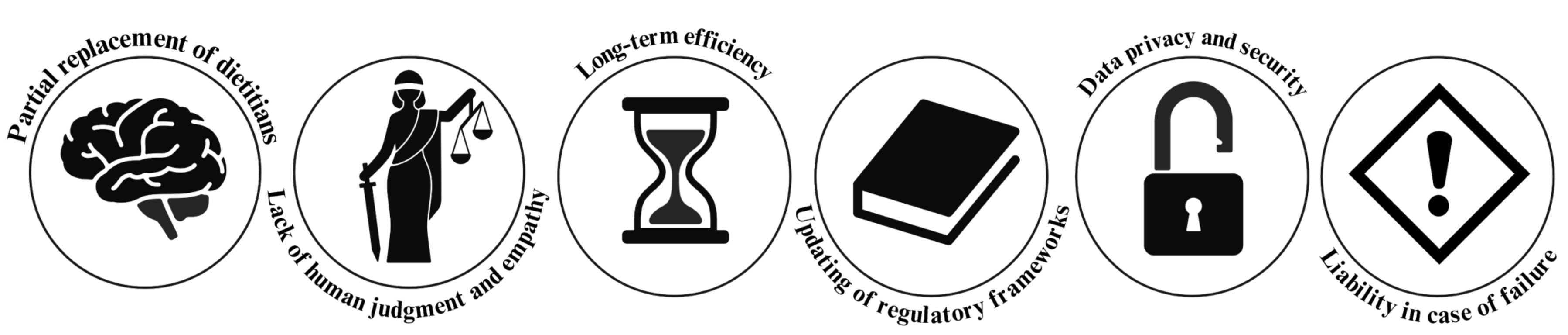
A computational infrastructure that combines data and tools to improve the monitoring of diet, the analysis of biomarkers, and the personalization of nutrition is outlined below:

Component	Purpose	Technology	Databases	Challenges
Diet databases	Track food intake patterns	Surveys, Apps	NutriBase	Cultural differences
Nutrient translation	Convert food to nutrients	Nutrition models	NutriDatabase	Food data variability
Biomarker data	Link diet biomarkers	Meta-genomics	NHANES	Testing accessibility
AI tools	Personalize advices	ML, AI algorithms	Nutrigenomix, MyFitnessPal	Model bias, privacy
Wearables & health	Real-time health metrics	Wearables, genomics	Fitbit, 23andMe	Interoperability
Feedback systems	Refine diet suggestions	ML Feedback loops	AI Nutrition Systems	Continuous trackin

(vi) Epigenomics for the search for nutritional biomarkers

- **Nutriepigenetics** focuses on how nutrition and environmental factors modulate gene expression while preserving the **genetic sequence.**
- **Major epigenetic mechanisms** include DNA methylation, histone modifications, and non-coding RNA.
- Calories, protein, fats, vitamins, minerals, and phytochemicals (polyphenols, catechins) influence the epigenetic state.
- **DNA methylation** is associated with metabolic response to dietary interventions at specific loci such as **ATP10A, WT1** and **TNFA.**
- These epigenetic changes are of particular importance in the **perinatal period,** but also take place in **adulthood.**
- **Epigenetic markers** can be **partially reversible**, which opens up the potential for personalized dietary interventions to prevent disease.
- Identification of **epigenetic biomarkers** enables personalized preventive treatments for individuals at **metabolic risk.**

(vii) Ethical considerations in the use of AI in nutrition



(viii) Considerations for the use of AI by health care workers

Must be able to **understand, interpret** and **explain** information given by the AI.

Be aware of the potential **risks**, and only use AI if the **benefits** outweigh the risks.

AI should be used by professionals in a **responsible manner.**

(ix) Conclusions and future directions

Overall, AI-based personalized nutrition, while very promising, still requires validation, while the regulatory framework should be constantly updated to keep pace with scientific progress and to address ethical issues.

A coordinated global effort in these fields may result in a more widely accepted adoption of AI by using biomarkers in nutrition in both individuals and populations.