OMICS Approaches to Understand Human Diseases

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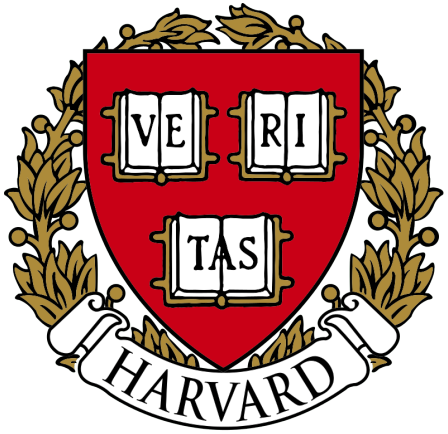
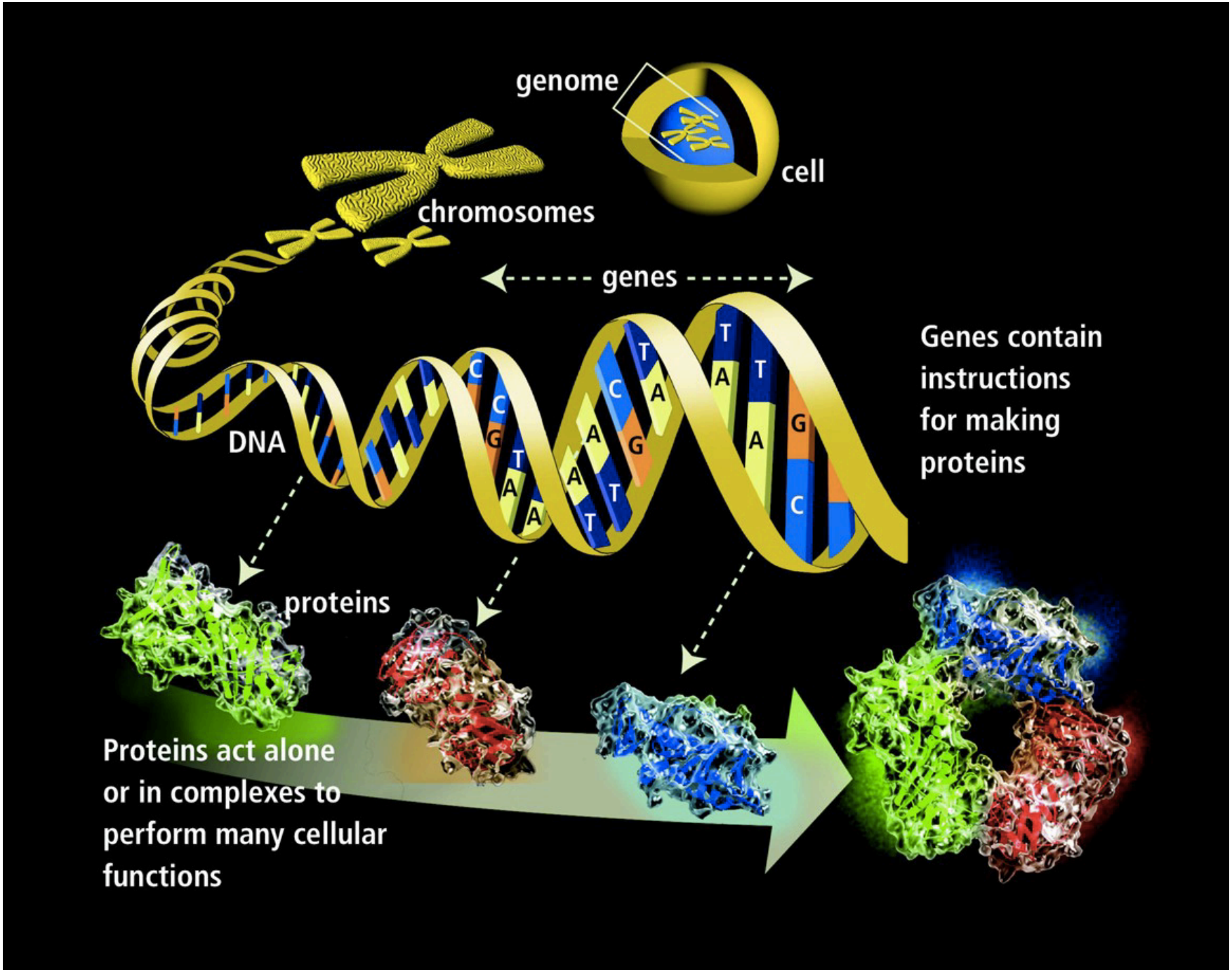
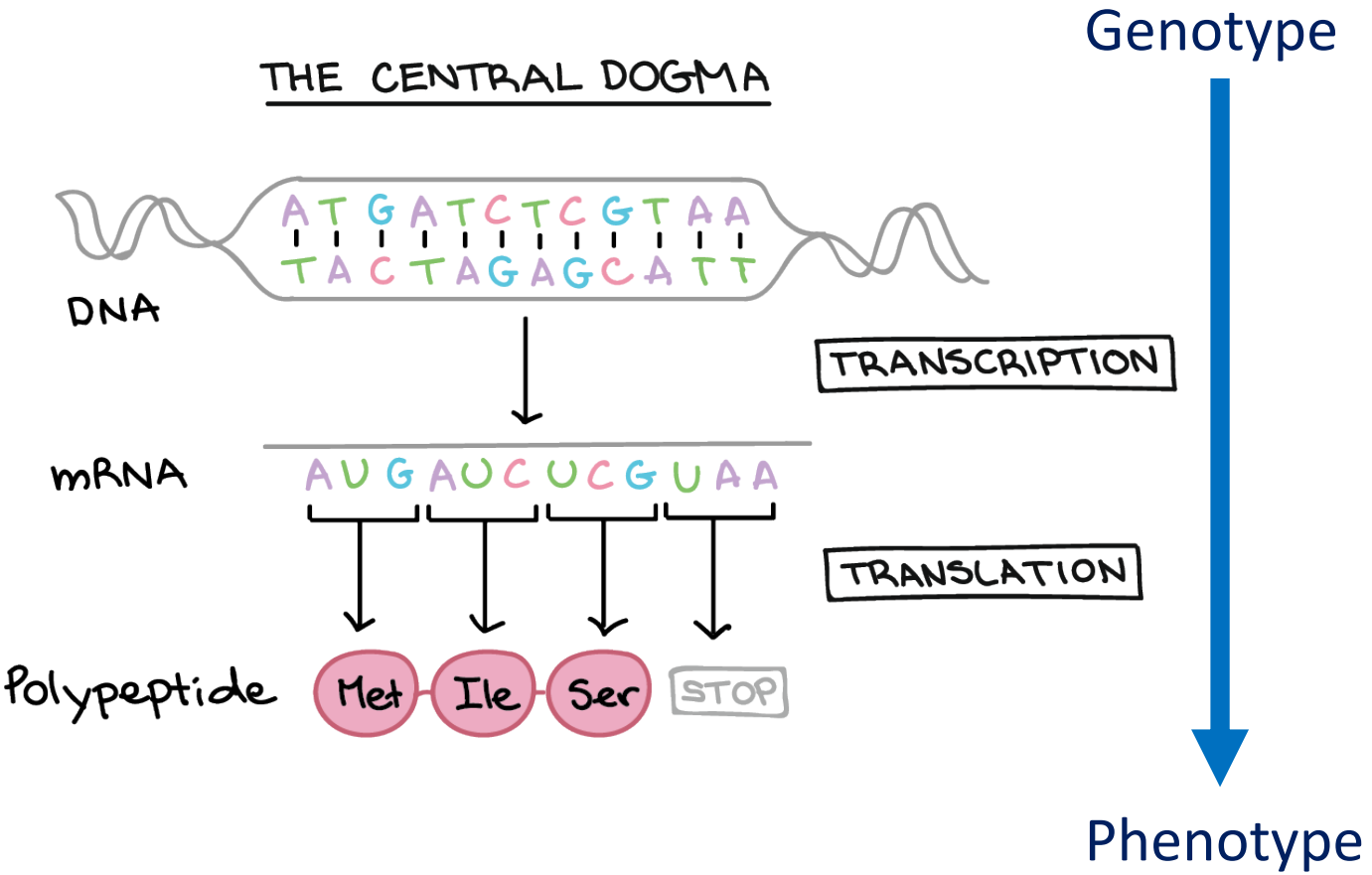
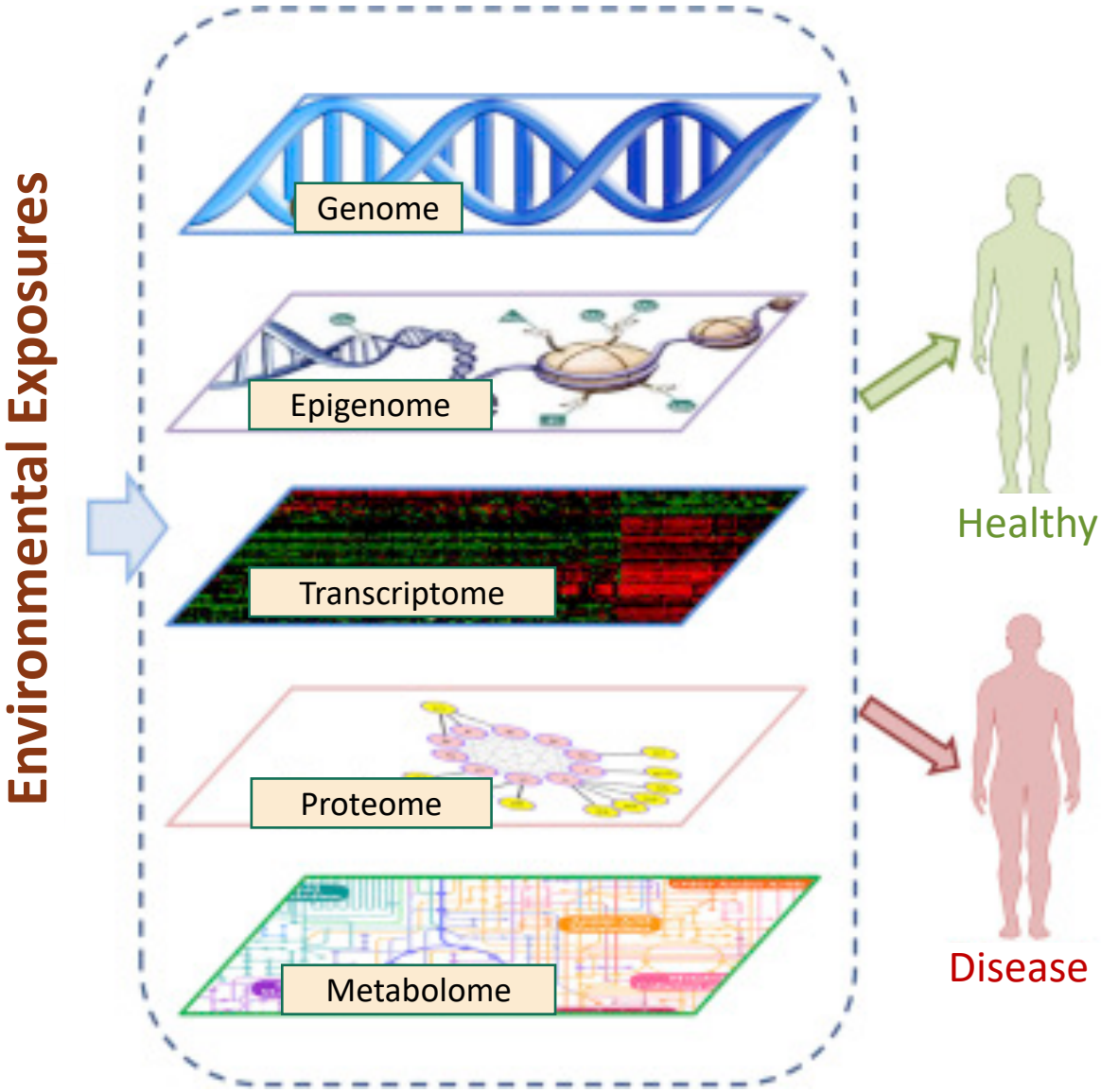



genome
cell
chromosomes
genes
DNA
Genes contain instructions for making proteins
proteins
Proteins act alone or in complexes to perform many cellular functions

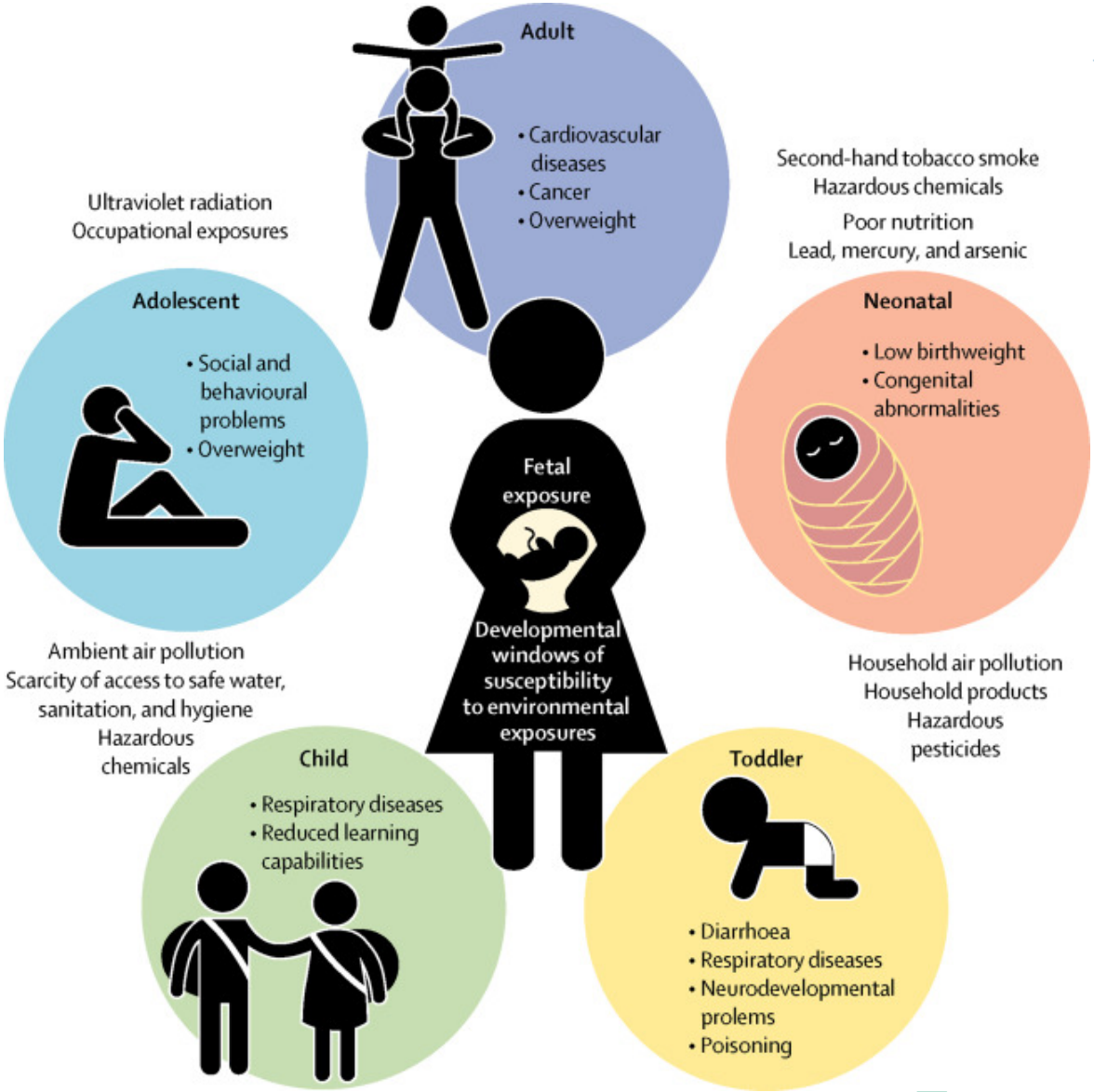
Central Dogma in Biology



Conceptual model of multi-omics and human disease



Sun and Hu, 2016


Adult
• Cardiovascular diseases
• Cancer
• Overweight
Second-hand tobacco smoke
Hazardous chemicals
Poor nutrition
Lead, mercury, and arsenic
Ultraviolet radiation
Occupational exposures
Adolescent
• Social and behavioural problems
• Overweight
Neonatal
• Low birthweight
• Congenital abnormalities
Fetal exposure
Developmental windows of susceptibility to environmental exposures
Ambient air pollution
Scarcity of access to safe water, sanitation, and hygiene
Hazardous chemicals
Household air pollution
Household products
Hazardous pesticides
Child
• Respiratory diseases
• Reduced learning capabilities
Toddler
• Diarrhoea
• Respiratory diseases
• Neurodevelopmental prolems
• Poisoning

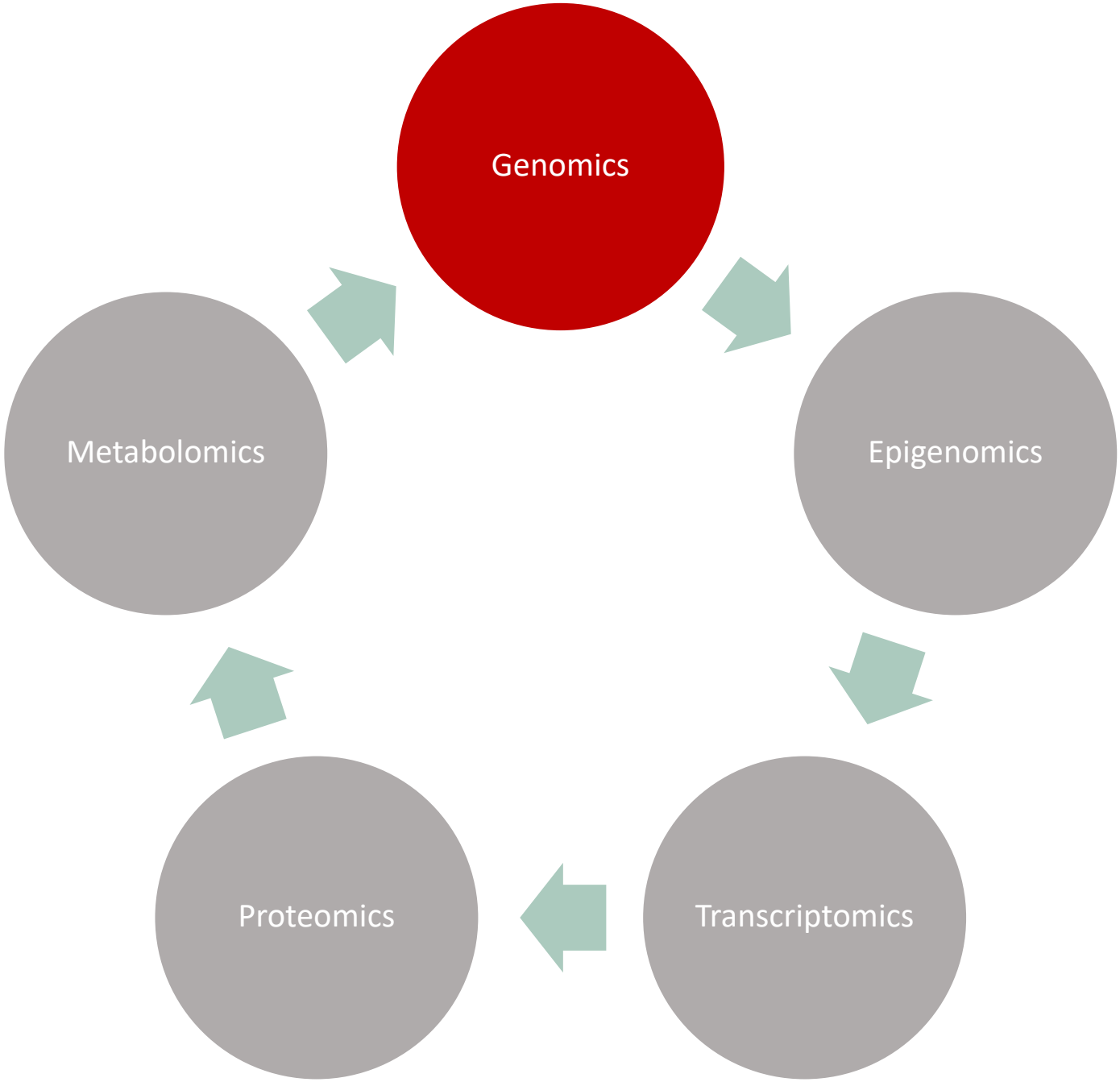
‘Omics’

- The word ’omics’ refers to a field of study in biology ending in the suffix -omics such as genomics, transcriptomics, metabolomics, or proteomics.

- Omics aims at the collective characterization and quantification of pools of biological molecules that translate into the structure, function, and dynamics of an organism or organisms.

Scope of Omics

- Determine biomarkers for diseases
- Differentiate biological pathways or processes between disease and control groups
- Greater understanding of flow of information, from the original cause of disease (genetic, environmental, or developmental) to the functional consequences or relevant interactions)
- Corner-stone for practicing 'Precision Medicine'

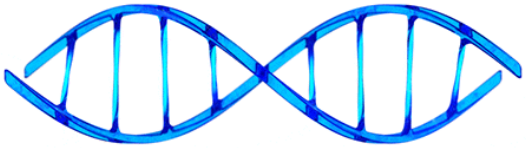

Genomics
Epigenomics
Transcriptomics
Proteomics
Metabolomics

Genomics

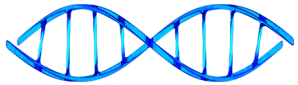
Genome structure, function, evolution, and mapping

- Genes
- Regulatory elements (promoters, enhancers)
- Genetic variation (DNA sequence, chromosome structure)

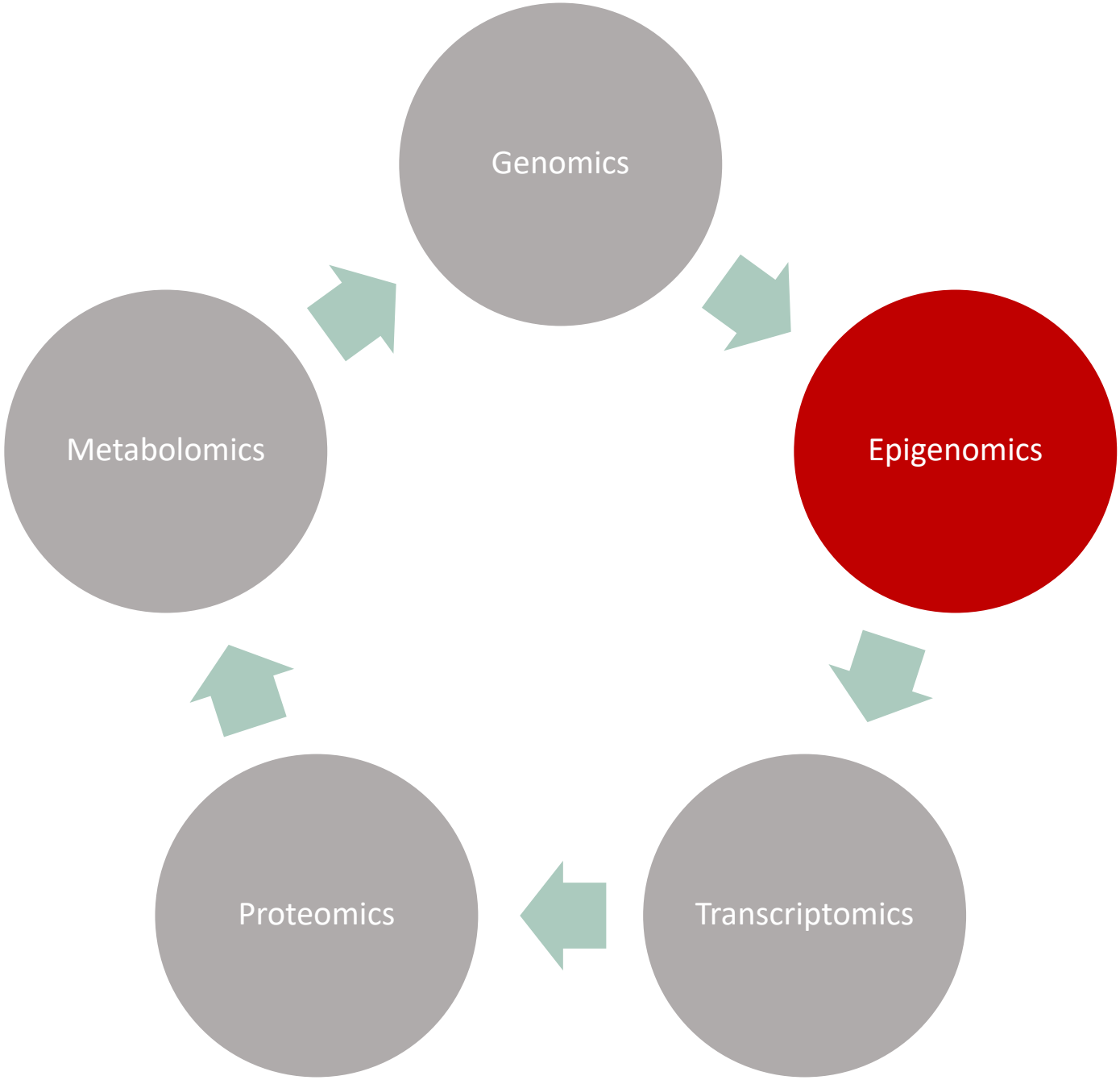
- Approaches: Whole genome sequencing, GWAS, Genotyping arrays, Exome sequencing, Genome Editing with CRISPR.



DNA



Genomic Approaches	Applications
Whole genome sequencing	Detect single nucleotide variants, insertions/deletions, copy number changes, and large structural variants
GWAS	Associate specific genetic variations with particular diseases
Genotyping arrays	Explore genetic variants such as single nucleotide polymorphisms (SNPs) and large structural changes in DNA
Exome sequencing	Diagnose the genetic cause of disease in a patient
CRISPR	Genome Editing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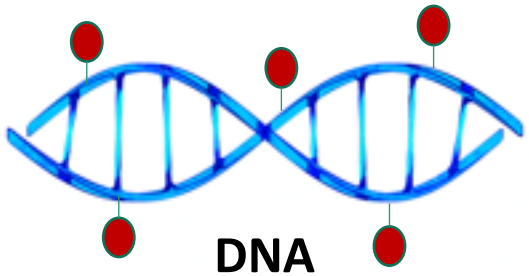
Epigenomics

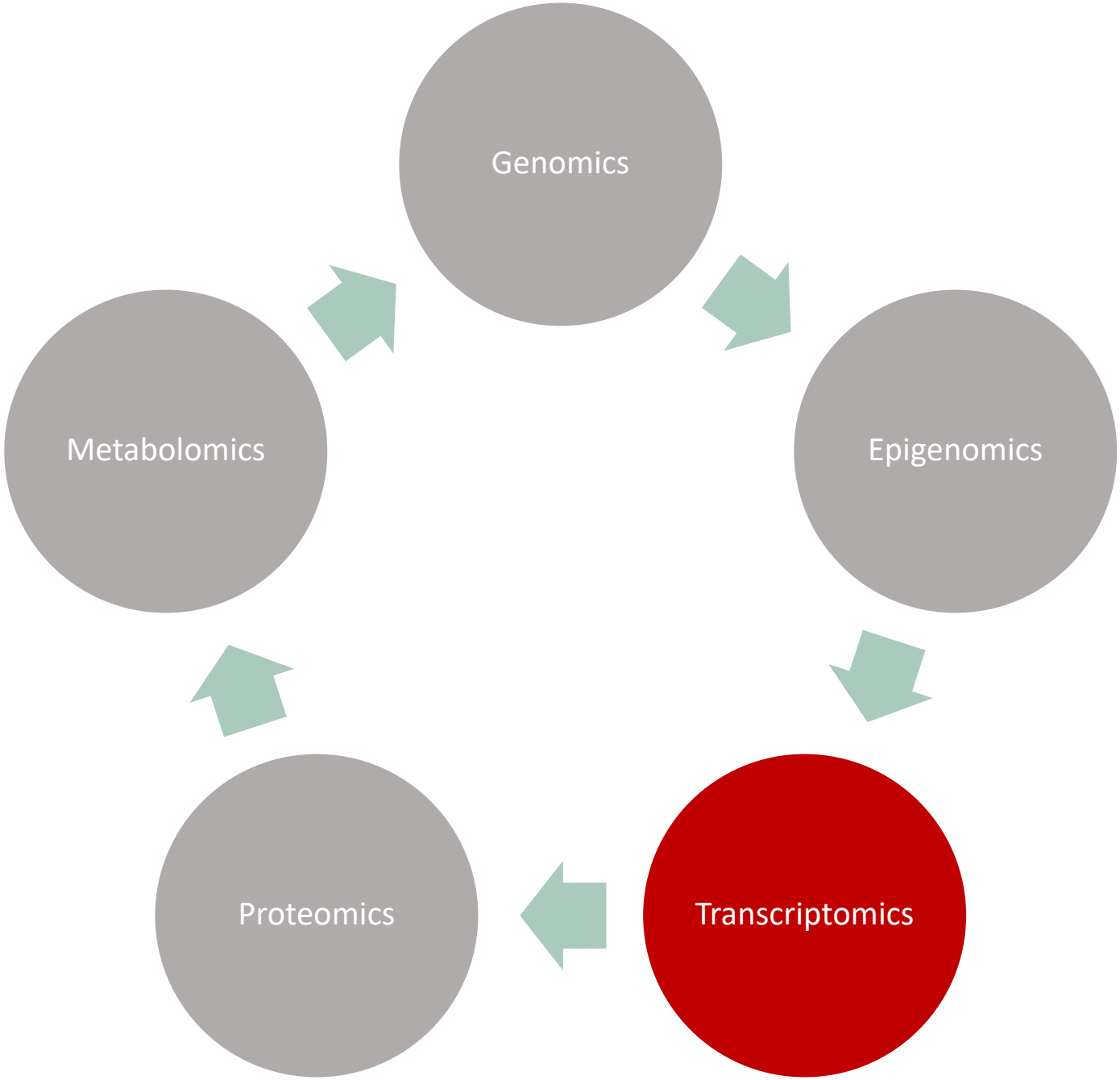
Chemical modifications to the genome

- DNA methylation
- Chromatin modifications (e.g., histone acetylation)
- Chromatin topology

- Approaches: Bisulfite sequencing, ATAC-seq, DNase-seq, ChIP-seq, Chromosome conformation capture (3C, 4C, 5C, Hi-C, ChIP-loop, ChIA-PET).



Epigenomic approaches	Applications
Bisulfite sequencing	Detect DNA methylation patterns
ATAC-seq	Detect accessible chromatin in the genome
DNase-seq	Determine chromatin accessibility
ChIP-seq	Determine DNA protein interactions
Chromosome conformation capture (3C, 4C, 5C, Hi-C, ChIP-loop, ChIA-PET)	Map the spatial chromatin organization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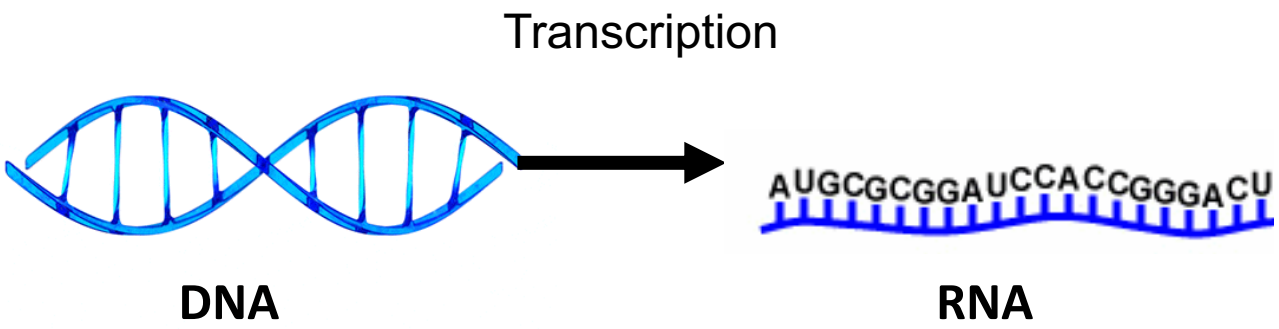
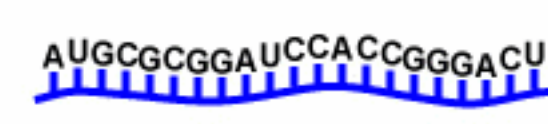
Transcriptomics

RNA transcripts produced by the genome

- Coding RNA (mRNA)
- Non-coding RNA species (e.g., lncRNA, microRNA, and other small RNAs)

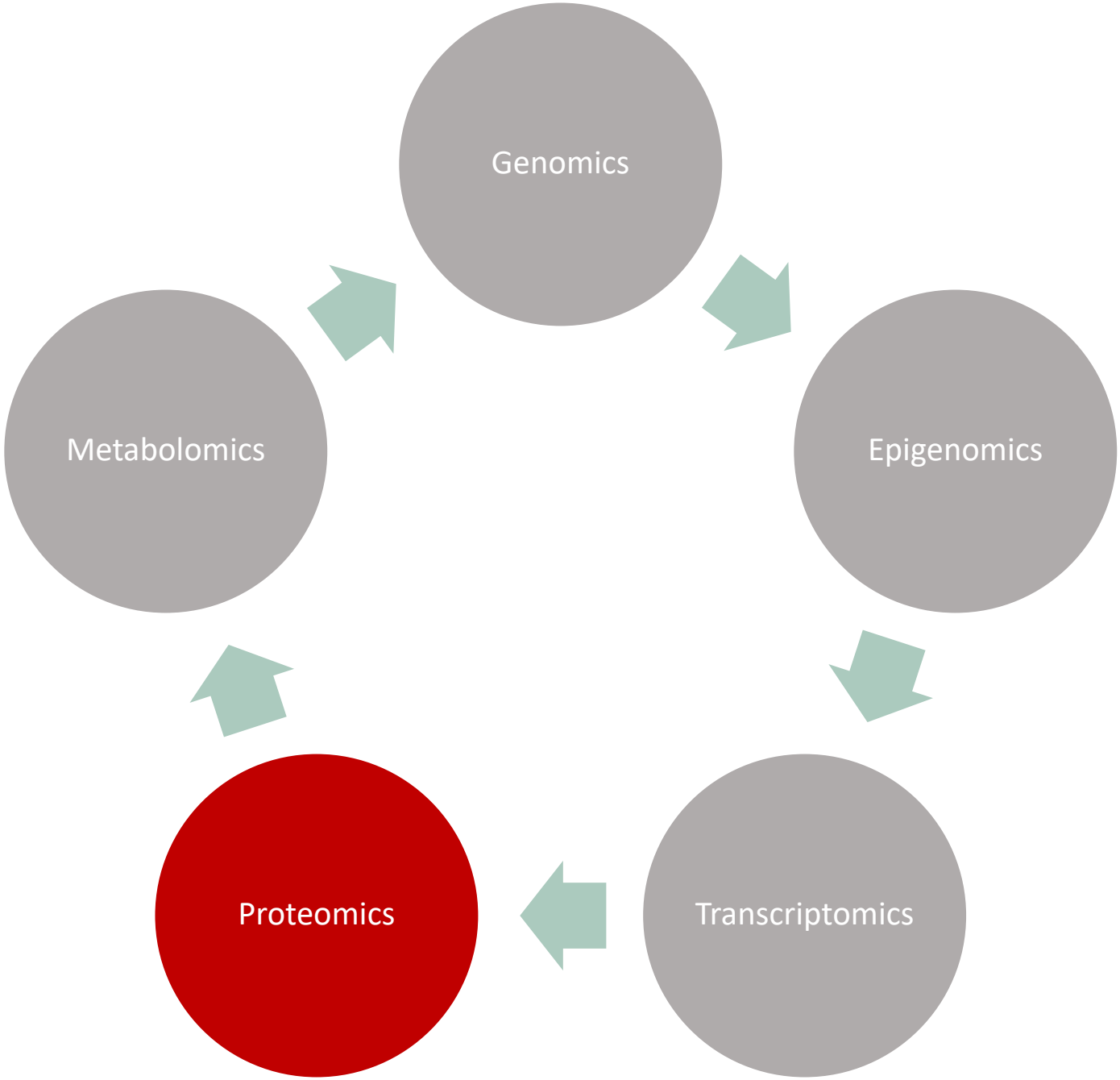
- Approaches: RNA-sequencing (mRNA, lncRNA, lincRNA, sRNA), iCLIP, etc.





RNA

Transcriptomic approaches	Applications
RNA-seq	Regulation of gene expression
Microarray	Regulation of gene expression
iCLIP	Identifying protein-RNA interactions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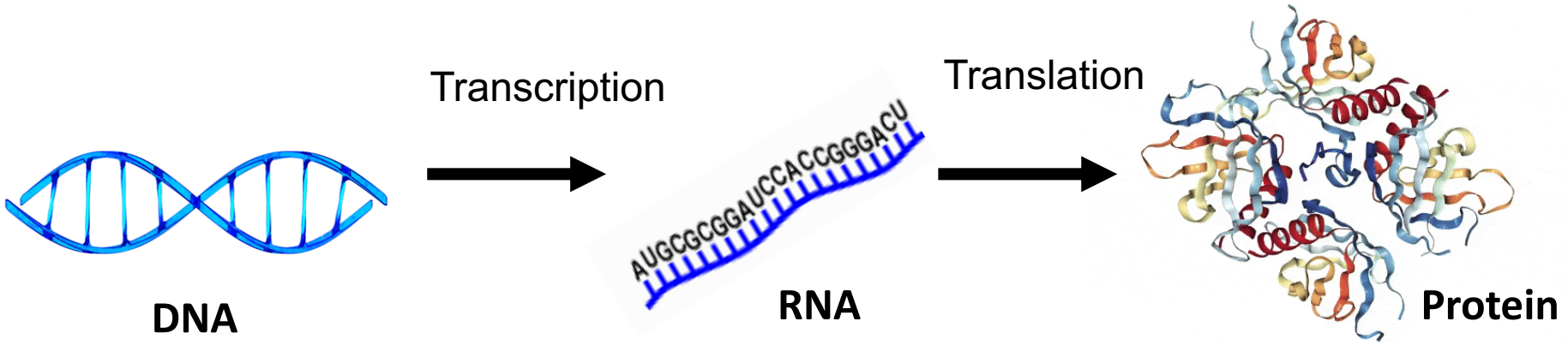
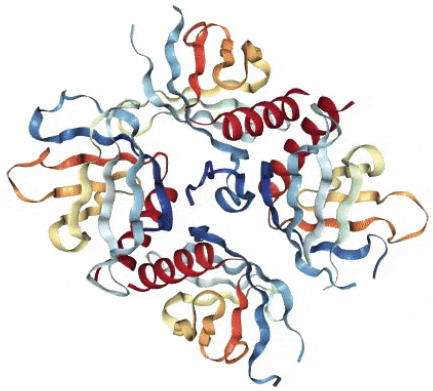
Proteomics

Proteins encoded by the genome

Approaches:

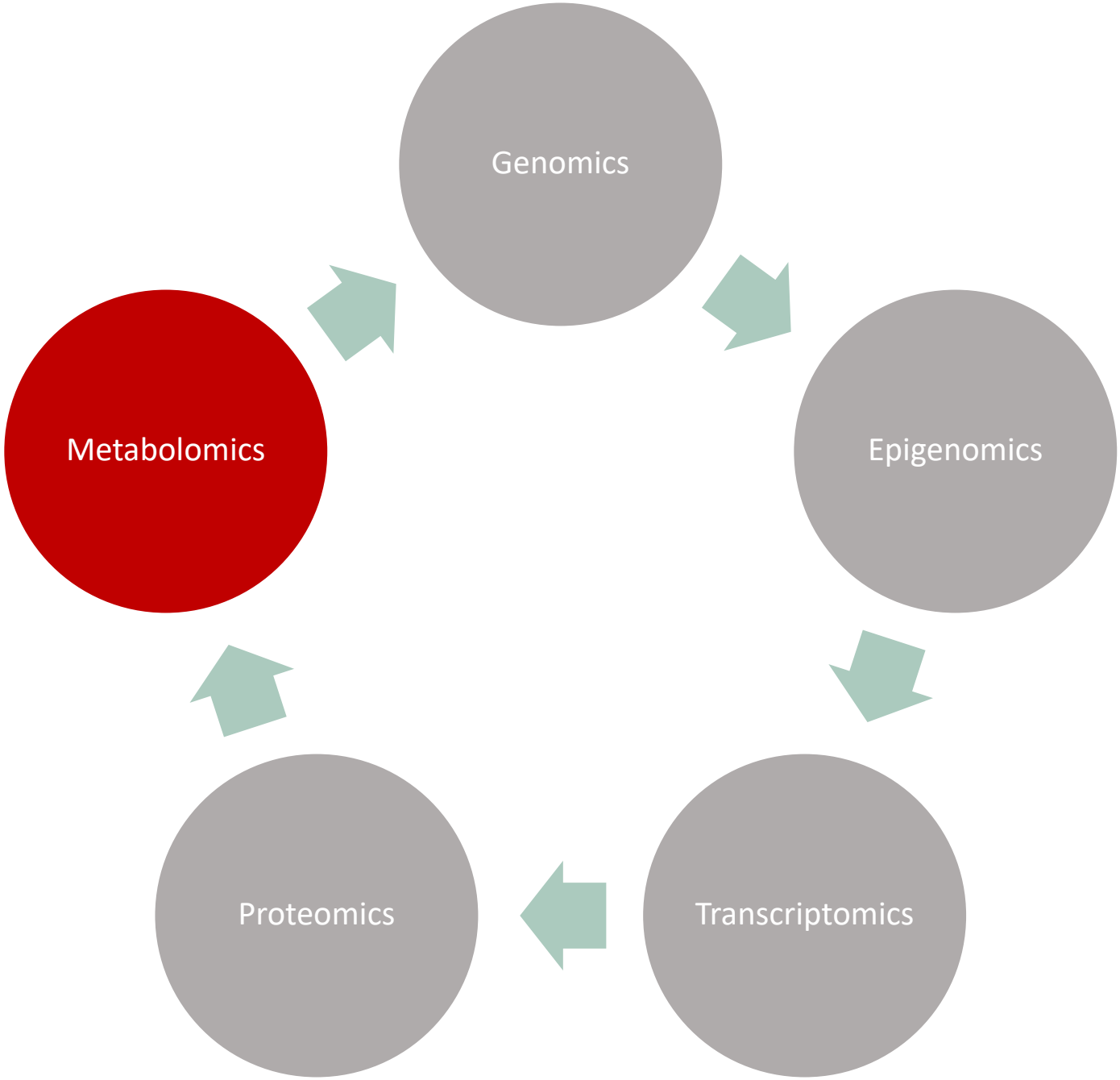
- Quantitative proteomics: Label free, metabolic labelling, Chemical labelling
- Interaction proteomics: AP-MS, XL-MS, IM-MS
- Organellar proteomics: proximity labelling, Protein correlation profiling, LOPIT
- Phosphoproteomics: IMAC, MOAC





Protein

Proteomic approaches	**Applications**
Label free, Metabolic labelling, Chemical labelling	Quantitative proteomics
Affinity Purification Mass Spectrometry (AP-MS), Crosslinking Mass Spectrometry (XL-MS), Ion Mobility Mass Spectrometry (IM-MS)	Interaction proteomics
Proximity labelling, Protein correlation profiling, Localization of Organelle Proteins using Isotope Tagging (LOPIT)	Organellar proteomics
Immobilized metal affinity chromatography, Metal oxide affinity chromatography	Phosphoproteomics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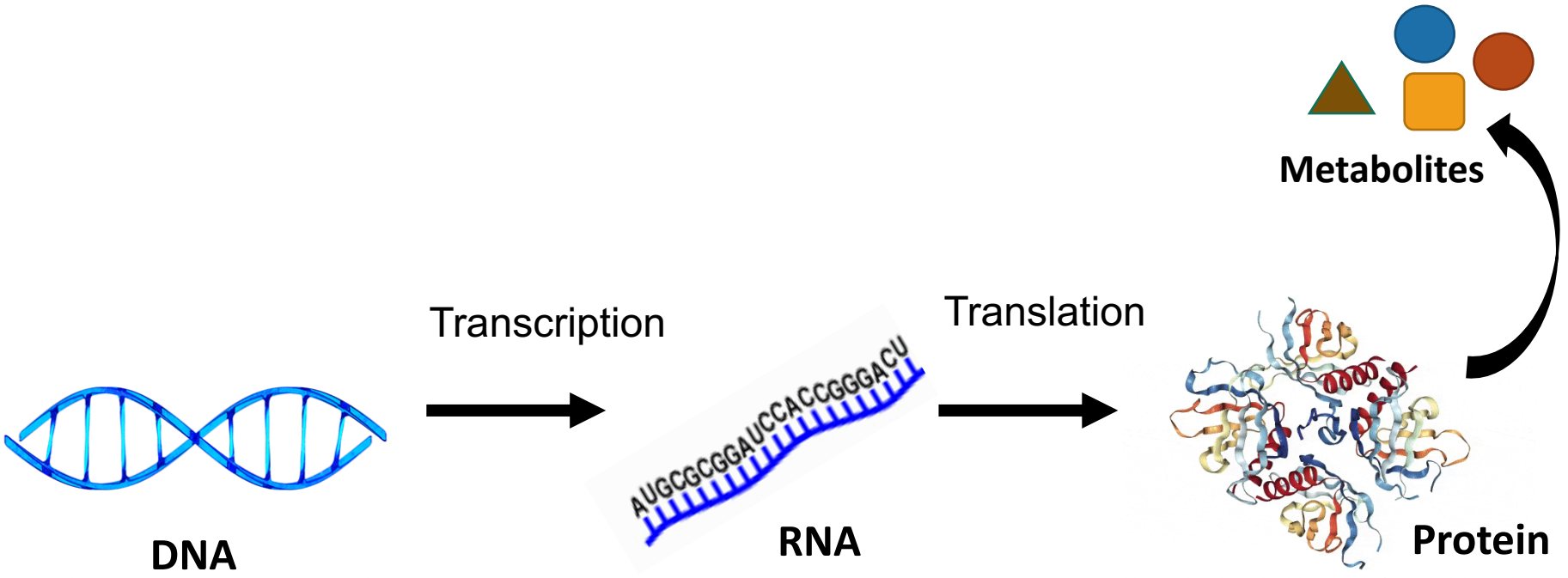
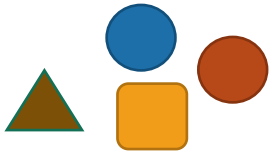
Metabolomics

Metabolites generated from metabolic reactions catalyzed by enzymes (proteins) within cells

- Metabolites (lipids, glycans, carbohydrates, amino acids)
- Analysis methods (steady state, pulse chase)

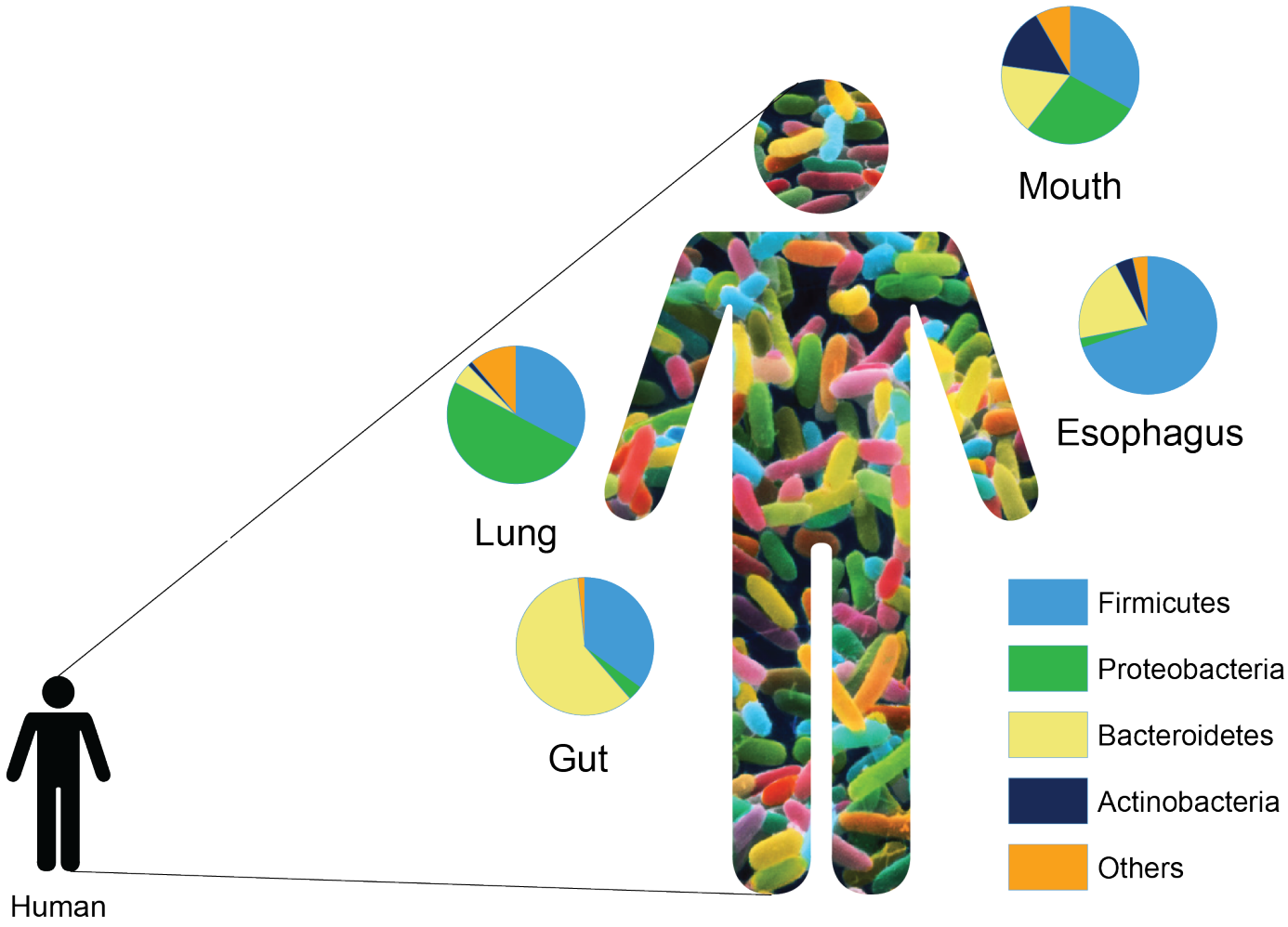




Metabolites

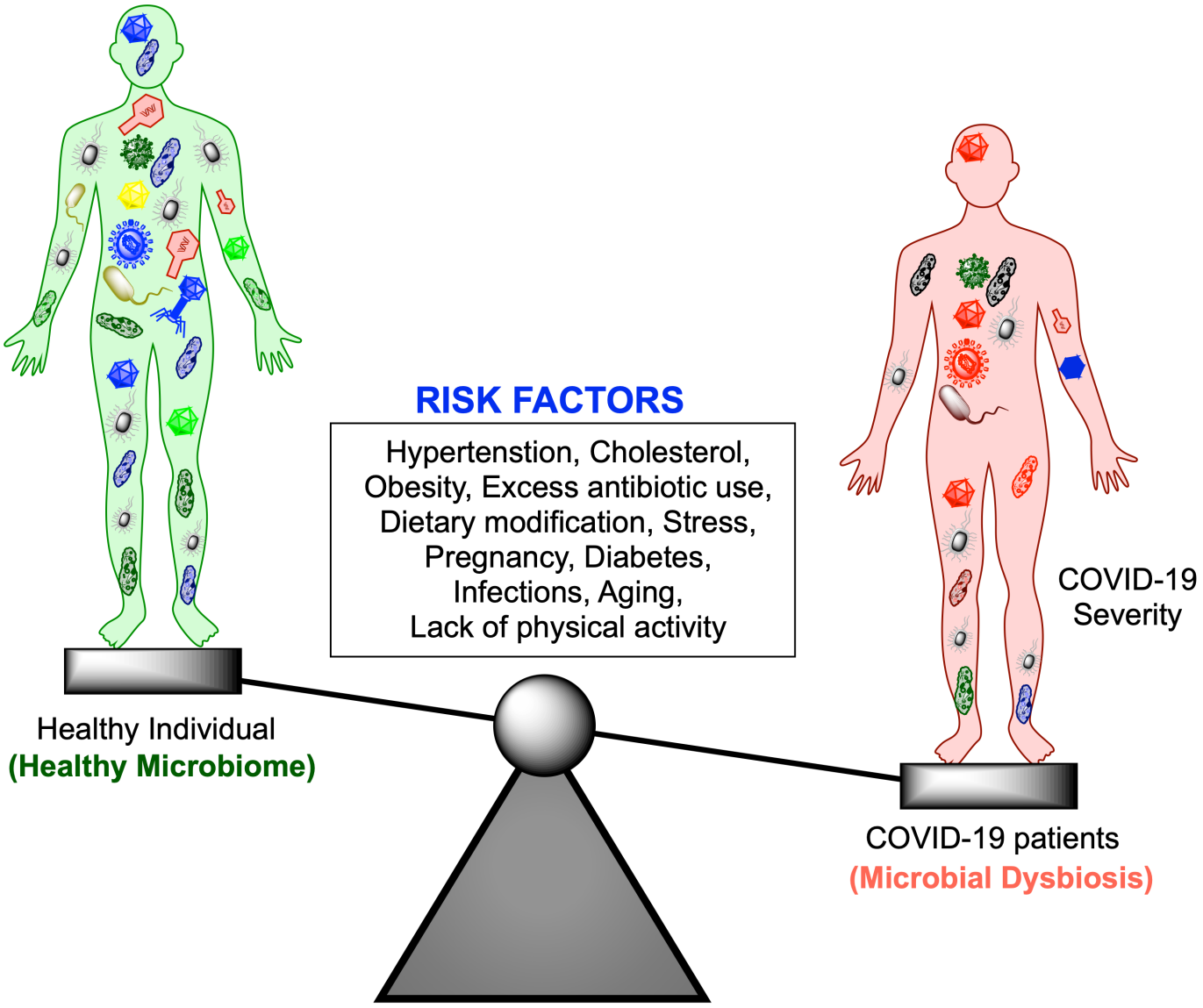
Approaches	Applications
Stable Isotope labelling followed by Mass spectrometry	Study of system wide metabolic regulation. Novel metabolites and pathways can be discovered

Microbiomics



https://www.intervals.science/resources/sbv-improver/microbiomics

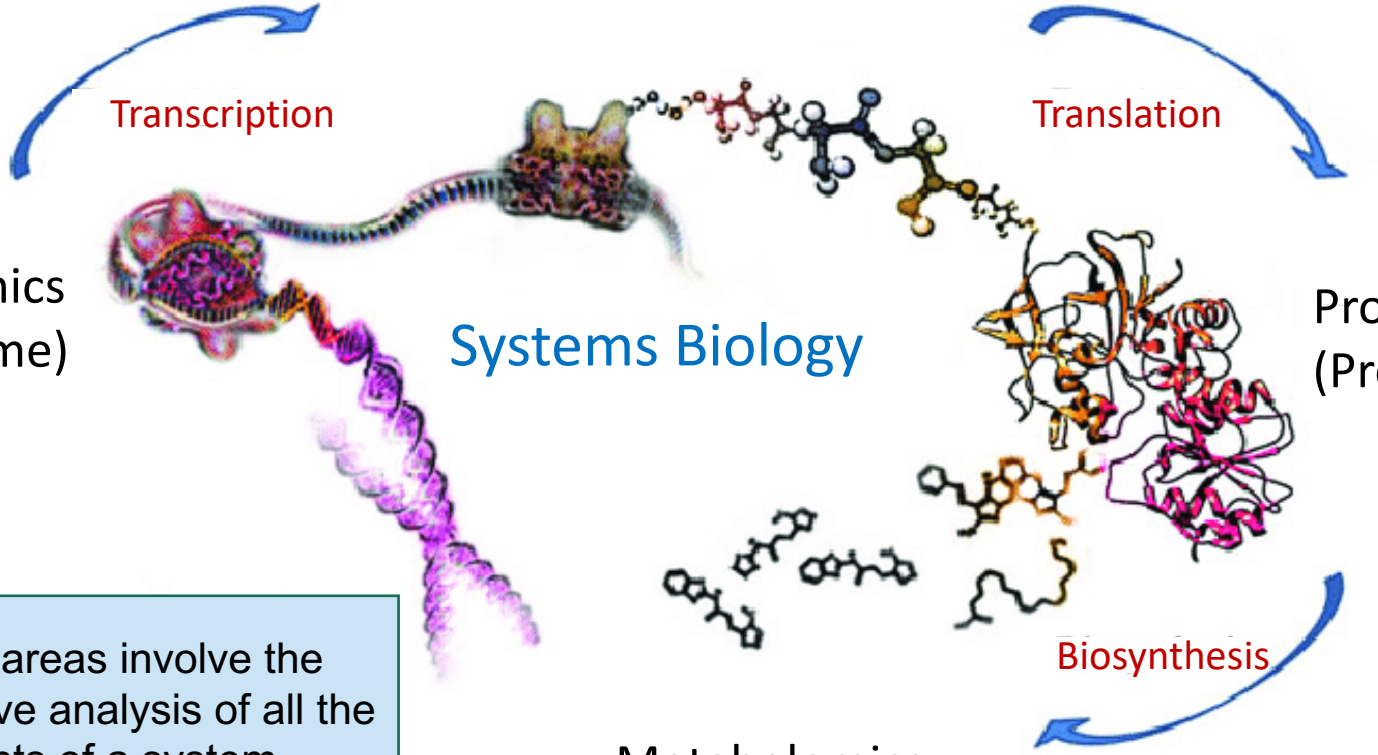
COVID-19



Muthuirulan et al (Unpublished)

System-wide analysis

Transcriptomics
(Transcriptome)



Metabolomics
Metabolome)

- All omics areas involve the quantitative analysis of all the constituents of a system
- In contrast to studying a single entity, omics approaches study an entire system

Medicine Today

Expectation

One Size Fits ALL

Reality

One Size Doesn’t Fits ALL

Genomics
Epigenomics
Transcriptomics
Proteomics
Metabolomics
Microbiomics

Omics Profile

Systems Biology, Bioinformatics, Biomathematics, Biostatics

Data Integration, Analysis and Interpretation

Precision Medicine

Complex Disease Network

Patient-Specific Interactions

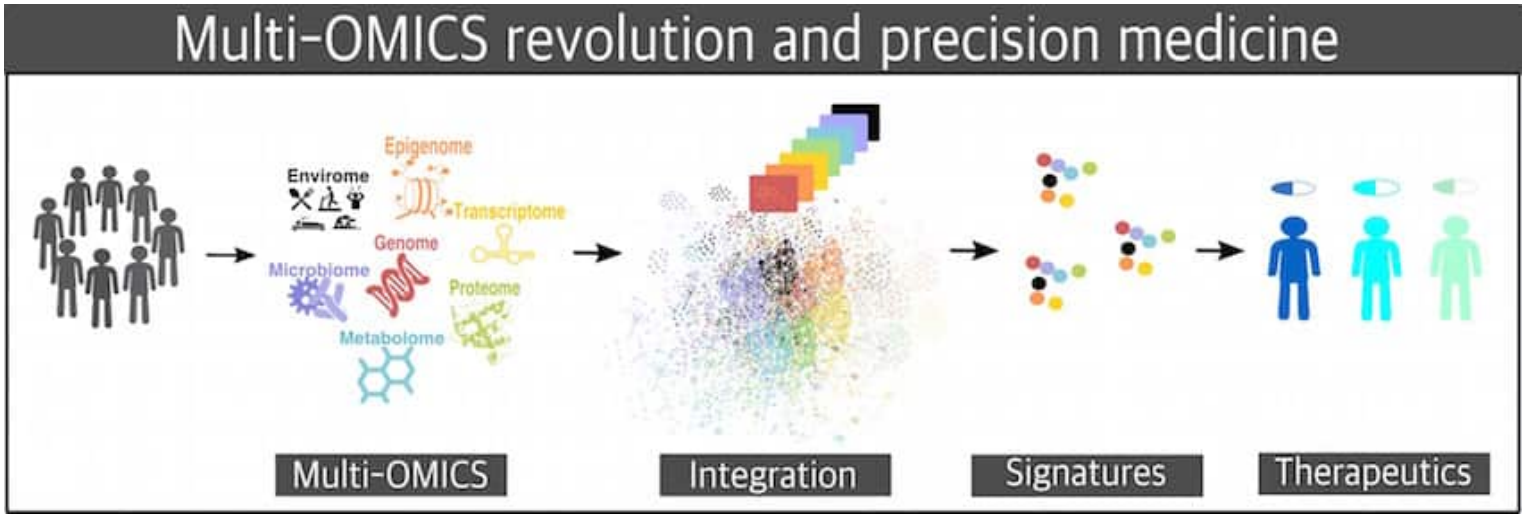
"Disease Signatures"

Care Delivery, Patient Education

Clinical Care

Precision medicine (**PM**) is a medical model that proposes the customization of healthcare tailored to a subgroup of patients, instead of a one-drug-fits-all model.

Thank you


Multi-OMICS revolution and precision medicine
Envirome
Epigenome
Transcriptome
Genome
Microbiome
Proteome
Metabolome
Multi-OMICS
Integration
Signatures
Therapeutics