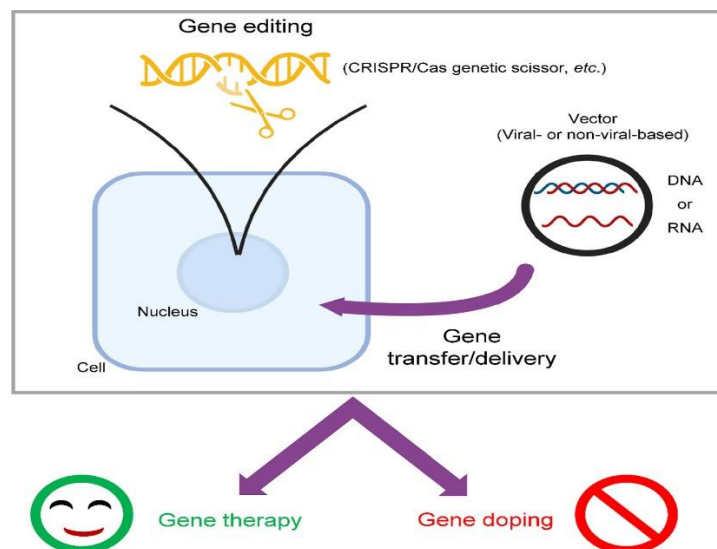


Emerging Doping Methods Vs. Anti-doping Countermeasures:

1. Gene Doping- Gene doping involves altering an athlete's DNA to enhance performance traits such as muscle strength, endurance, or recovery speed. This is done using gene-editing tools like **CRISPR** or by **injecting modified DNA**. The changes can make athletes produce more red blood cells or build muscle faster, mimicking natural abilities.

Countermeasures:

- a. **Gene Testing:** Anti-doping agencies use advanced gene sequencing to identify unnatural modifications in an athlete's DNA.
- b. **Biological Passports:** Athletes' genetic profiles are monitored over time to detect abnormal changes or patterns that suggest tampering.
- c. **Research Partnerships:** Scientists work with anti-doping agencies to develop tools for detecting new gene-editing techniques.

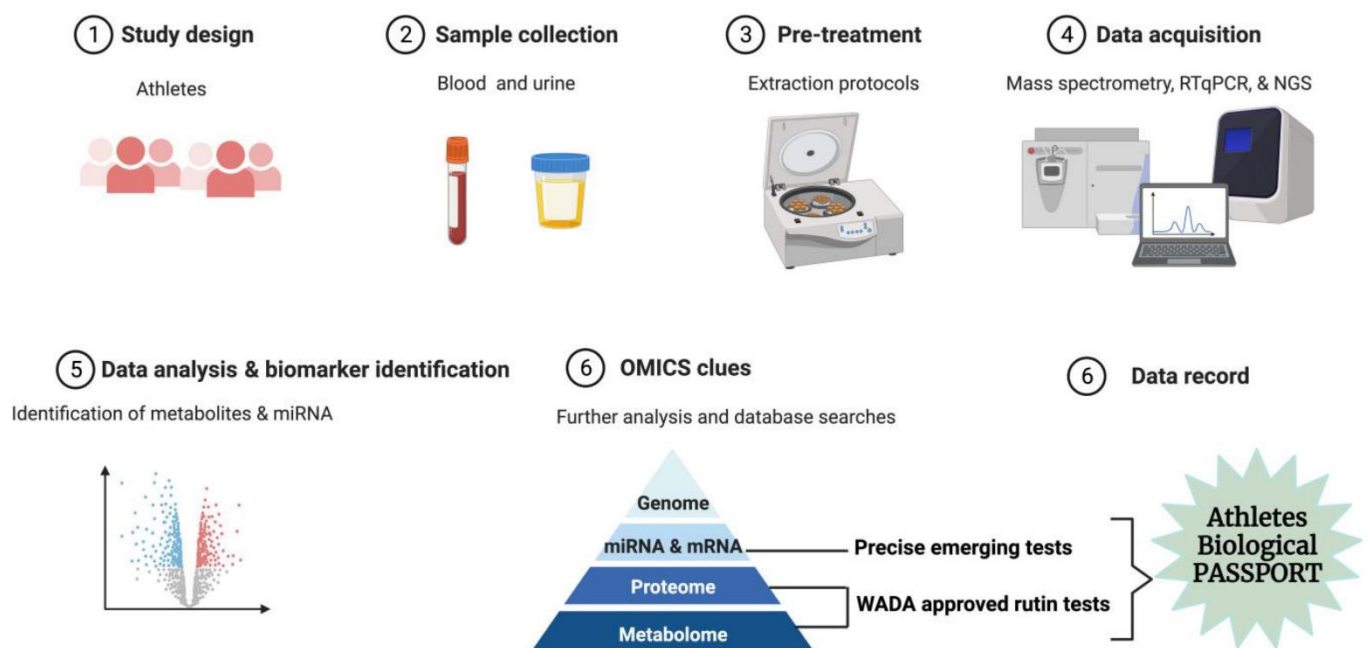


2. Microdosing- Microdosing involves taking very small amounts of banned substances like EPO (which boosts red blood cells) or testosterone (which builds muscle). These doses are carefully timed to enhance performance while staying below the detection thresholds of conventional drug tests.

Countermeasures:

- a. **Random and Frequent Testing:** Conducting surprise tests at unexpected times increases the likelihood of detecting traces of the substances.
- b. **Blood Biomarker Tracking:** Using the Athlete Biological Passport to track small changes in blood parameters (like hemoglobin levels) over time.
- c. **Advanced Analytical Techniques:** Using sensitive drug testing equipment that can detect even trace amounts of substances missed by earlier methods.

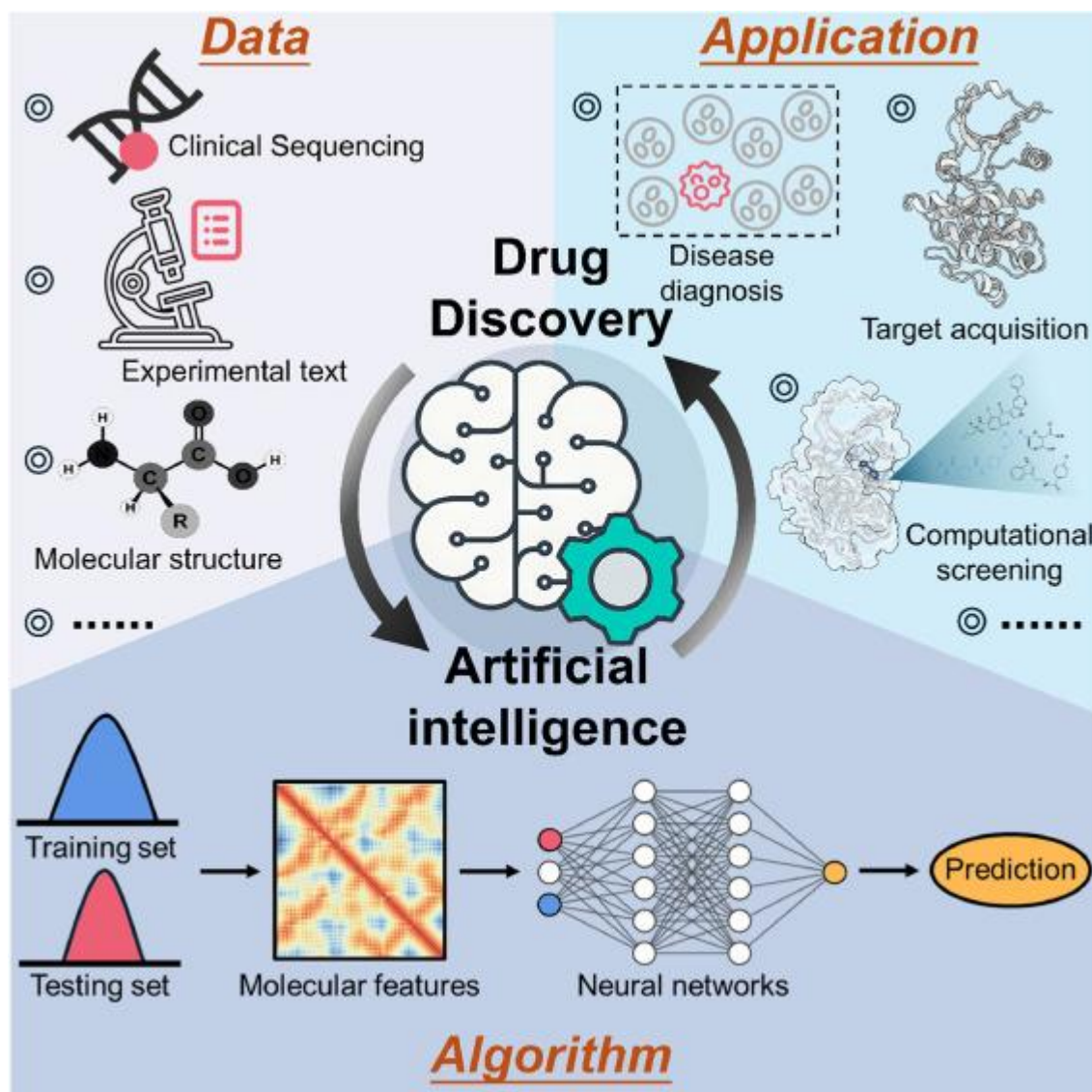
Un/targeted Metabolomics & Transcriptomics for Doping Biomarkers Discovery



3. Designer Drugs- Designer drugs are chemically altered substances created specifically to mimic the effects of banned drugs while avoiding detection by current testing methods. These drugs often have unique structures that are not on the anti-doping agencies' banned substance lists yet.

Countermeasures:

- a. **Testing Library Expansion:** Anti-doping labs constantly expand their testing protocols by including newly discovered designer drug molecules.
- b. **Collaboration with Pharmaceutical Companies:** Drug companies share data on experimental or unapproved substances to help anti-doping labs stay ahead of new doping trends.
- c. **Global Intelligence Networks:** Anti-doping agencies collaborate internationally to track and exchange information on emerging substances.



4. Blood Doping with Advanced Methods- Blood doping enhances performance by increasing the oxygen-carrying capacity of blood. This can involve transfusing stored blood, injecting synthetic oxygen carriers, or using advanced techniques to boost natural red blood cell production. It allows athletes to sustain high performance during endurance events.

Countermeasures:

- a. **Biological Passport:** Tracking an athlete's blood parameters (e.g., hemoglobin levels, reticulocytes) over time to spot abnormalities or sudden spikes indicating manipulation.
- b. **Synthetic Carrier Detection:** Labs use specialized tests to identify artificial oxygen carriers, such as perfluorocarbons or hemoglobin-based oxygen carriers.
- c. **In-Competition Testing:** Coordinated blood testing during competitions when the effects of blood doping are most beneficial to athletes.

5. Wearable Device Manipulation- Athletes use wearable devices like Apple Watch, Garmin Forerunner, Fitbit Sense to alter or fake physiological data, such as heart rate or oxygen levels, to mislead anti-doping authorities or mask signs of doping. Wearables can also provide real-time feedback on drug effects, allowing athletes to optimize doping schedules.

Countermeasures:

- a. **Independent Monitoring Devices:** Anti-doping organizations require athletes to use devices provided by neutral parties to ensure data accuracy.
- b. **Data Verification:** Auditing wearable device data against other biological markers (e.g., blood or urine tests) to detect discrepancies.
- c. **Educational Campaigns:** Informing athletes and support staff about the risks and ethical implications of wearable device manipulation.