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Role of Chemistry in Personalized Medicine

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Wellbeing of a person is a crucial factor in life which facilitates the performance of his or her day to day routine work in well-organized manner. However, it is a known fact that we all get sick and we need to take suitable medicines accordingly, as prescribed by clinicians. Even though millions of people are taking medications daily, they are found to be effective only on a part of the population who use them. Some drugs, such as 'statins' which are frequently used to lower cholesterol are known to be effective only on 1 in 50 patients. On the other hand, some drugs cannot be metabolized by some people leading to arouse toxicity and allergy on them. Thus, the importance of the identification of this personal difference in medication has now been considered in designing and prescribing drugs for different diseases, opening avenues to the new paradigm in medicine, '**personalized medicine (PM)**'. Hence, personalized medicine represents the alignment of medical treatments to the individual characteristics of each patient, which are determined by the genetic make-up or the genome of that particular patient. This new approach of medicine is based on the revelations on the correlation between person's unique molecular or genetic profile and certain diseases. Ultimately, PM can predict the safety and effectiveness of a medical treatment on each individual, enhancing the precision of the treatment based on the molecular profile of the patient, by reducing harmful side effects and ensuring the successful outcomes on the patient. Cancers including breast cancers and cardiovascular diseases are the prominent candidates to be treated using PM approach.

Personalized medicine relies on the interdisciplinary research not only to find out specific bio-markers to diagnose a disease or predict the risk of having it, but also to deliver targeted treatment to each individual or group of individuals suffering from the disease. In this regard, medicinal chemistry which overlaps with different disciplines of science, including organic chemistry, bio-organic chemistry, physical organic chemistry, biochemistry, pharmacology, toxicology, analytical chemistry, molecular biology and genetics play a major role to build up the bridge between chemistry and PM. Medicinal chemistry can greatly catalyze the process of drug discovery and development, with the collaboration of pharmaceutical industry to bring new medicines from bench to market. Not like in early ages, complex synthetic methods and technologies such as combinatorial chemistry (comb-chem), microwave assisted organic synthesis (MAOS) and high-throughput (HTS) biological screening methods are accompanied with new drug discovery programs which accelerate the process of discovery. Comprehensive knowledge of the synthetic chemistry, computational chemistry, and biology literature ultimately can propel the discovery forward until it passes to the end market. Finding of potential drug targets has now been enhanced by the knowledge of molecular biology, especially the information on human genome and proteome (total protein content of a given organism, tissue or a cell at a given time). Medicinal chemists use this information to identify relevant targets capable of being affected by the interactions with candidate drug compounds. This process is now been facilitated by different computational approaches, such as 'molecular docking', in which interactions between drug targets, especially protein molecules and drug molecules are predicted. Subsequently, those candidate drug molecules are short listed according to their effectiveness to choose the best candidates before proposing, synthesis and testing for direct action on protein targets, in order to effectively treat a wide variety of diseases. Herein, chemist can analyze the interaction of the drug with the wide array of target molecules which depends on the personal variation. Thus, he or she can modify the structure of the drug to be more suited for the particular patient or the group of patients.

Molecular biology in combination with computational chemistry, especially computer based drug designing has now enabled chemists to rationally design new drug molecules targeting the known bio-molecules. Compared to the traditional methods in developing a drug against a disease, this new approach saves time and allows for a more comprehensive understanding of the drug-target interplay. In this process, initially the major molecule/s which show/s the desired biological activity should be identified using new technologies such as HTS and combinatorial chemistry. Thereafter, those molecules need to be modified and optimized, by using structure-activity analysis (SAR) in order to improve the desired pharmacological properties
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by considering absorption, distribution, metabolism, and excretion of the molecule/s. Finally, the optimized molecule/s should be scaled-up for further drug development process and efficacy testing.

In the area of bio-marker studies related to PM, antibodies used as molecular probes have now been replaced by 'aptamers' which are single-stranded synthetic oligonucleotides composed of DNA or RNA, with a length of 20-100 nucleotides. These aptamers are promising molecules with binding affinity to a variety of targets such as metal ions, small molecules, proteins, and intact cells. Aptamers are produced by an *in-vitro* selection process called 'Systematic Evolution of Ligands by Exponential Enrichment (SELEX)' depending on chemical artistry. They are chemically synthesized and can be designed to conjugate with other molecules such as bioaffinity molecules, chemical linkers and nanomaterials. Thus, aptamers are used as indispensable molecular tools for biomarker studies.

In summary, PM is becoming promising field in medicine which improves the precision of medications based on personal variations of patients due to the diversity of their genetic make-up. Chemistry, especially medicinal chemistry plays a significant role in PM to enhance its efficacy by proposing and synthesizing drug molecules based on computational approaches in drug development programs. Moreover, chemical synthesis of different molecular probes solely based on chemical artistry has improved the efficacy on bio-marker based studies in drug development. Likewise chemistry in collaboration with modern molecular techniques is ever moving the field of medicine forward, especially with the novel approaches like PM, speed of which is also getting enhanced day by day on as a result of the promising researches in the field of medicinal chemistry.

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Photochemical Water Reduction by Organic Hydrides

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Increasing concerns on anthropogenic climate change, skyrocketing global energy needs, and depletion of fossil fuels have made the discovery of alternative carbon-neutral and sustainable energy sources, one of the most urgent challenges in the scientific community. Among many renewable energy sources, solar energy stands out as the most promising candidate since it is the highest exploitable resource, delivering more energy in one hour to the earth surface than the amount of energy that we consume worldwide in an entire year. However, its nature of diurnal variation, intermittence, and unequal distribution requires efficient and cost-effective capture, conversion, and storage. Molecular fuels produced from solar energy input represent an promising approach to meet this goal, due to the high energy density that can be stored within chemical bonds. As such, hydrogen generated from solar-driven water splitting has been widely considered as an attractive option; the sole product of hydrogen combustion is water, rendering a carbon-neutral energy cycle, and the substrate water is by far the most abundant chemical on earth. However, water splitting involves the transfer of multiple electrons and protons ($2H_2O \rightarrow O_2 + 4H^+ + 4e$ and $2H^+ + 2e \rightarrow H_2$), hence catalysts are needed to make it energetically feasible.

The molecular hydrogen-evolving catalysts are more diverse than the corresponding water-oxidation systems, due to the fact that proton reduction involves a relatively simple, two-electron transfer step. For this reason, molecular hydrogen-evolving electrocatalysts can be directly coupled with a light-absorbing chromophore to achieve the photocatalytic process. The electrocatalysts that are currently explored fall into several major categories: (i) bimetallic Ni-Fe and Fe-Fe based catalysts inspired by natural hydrogenases; (ii) monometallic Co, Ni and Mo based catalysts, which generally evolve H_2 *via* Co(III) or Mo(IV) hydride species generated by the reaction of protons with electrogenerated Co(I) or Mo(II) intermediate. Some of
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