

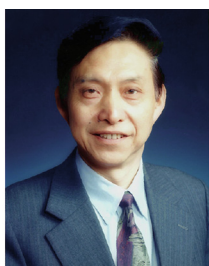


## Editorial

## The Quest for the Modernization and Internationalization of Traditional Chinese Medicine

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Traditional Chinese medicine (TCM) is deeply rooted in ancient Chinese culture and has been practiced by Chinese people for thousands of years in order to maintain their health and fight against disease. This ancient Chinese wisdom has accumulated from the long struggle to cope with various diseases through hundreds or even thousands of trial-and-error practices. However, due to its empirical character, TCM has long been criticized as being deficient in scientific evidence, and is still not widely accepted by the mainstream conventional medical system. The complexity of the chemical components of TCM and the clarification of its mechanisms remain an enormous challenge in the conversion of TCM into an evidence-based medicine. Thanks to incredible progress in biomedical research, TCM has evolved at an astonishing pace in various aspects, as indicated by the 2015 Nobel Prize awarded to Professor Youyou Tu for her discovery of artemisinin.

In 1996, the Chinese government launched the Action Plan for Modernized Science and Technology Industry of TCM (hereinafter TCM Modernization Plan), which was aimed at endowing TCM with ample scientific evidence in terms of its safety, efficacy, quality, modes of action, mechanisms, and so forth. After 20 years of arduous exploration, dramatic progress has been achieved in Chinese herbal cultivation, TCM chemistry, TCM pharmacology, processing, quality control, safety, efficacy validation, good manufacturing practice (GMP) manufacturing, the TCM pharmaceutical industry, and more. Since the implementation of good agricultural practice (GAP) in Chinese materia medica in 2002, over 100

commonly used Chinese herbs have been cultivated by standard operating procedure (SOP) in accordance with GAP requirements; these herbs include *Salvia miltiorrhiza*, *Astragalus membranaceus*, *Panax notoginseng*, *Glycyrrhiza uralensis*, *Isatis tinctoria*, and many more. Research on TCM chemistry and phytochemical analysis has reached new heights as well, with more than 6000 new natural products having been isolated and characterized from TCM herbs, including a great number of bioactive compounds with potential for development into new drugs. With the rapid development of hyphenated technologies, the number of components characterized in a single herb through sheer phytochemical analysis is growing by geometric progression into the hundreds or even thousands, which greatly facilitates the elaboration of TCM quality standards.

The paradigm of TCM quality control has shifted from a single-marker model to a holistic approach with fingerprint profiling and multicomponent assays as the prominent features, in order to enable the evaluation of batch-to-batch consistency and overall quality. TCM globalization has also progressed in an unprecedented manner, with nine finished TCM products currently in phase II or phase III clinical trials for US Food and Drug Administration (FDA) registration. Over 15 quality standards of Chinese herbs have been adopted in the *United States Pharmacopeia* and 75 TCM quality monographs have been recorded in the *European Pharmacopoeia*. The gross value of the industrial output of TCM has reached a new high of over 800 billion CNY (about 118 billion USD), which is 20 times greater than the value in 1996, the starting year of the national TCM Modernization Plan.

To reflect recent progress and development in TCM research and to outline future perspectives in this field, we have organized this special issue dedicated to TCM modernization and internationalization. Fourteen articles, covering an array of research directions, were invited from prominent scholars and researchers in the field. Majority of these articles are now published in this issue, the following will be published in the future issues. In this special issue, Youyou Tu and her colleagues review the past, present, and future of artemisinin. The antimalarial mechanism of artemisinin, the challenge to fight against emerging artemisinin-resistant malaria, and the potential use of artemisinin to treat diseases other than malaria, such as cancer and lupus erythematosus, are

discussed in this review. Professor Lan-Juan Li and her colleagues discuss new and increasing evidence of the relation between gut microbiota and host health, which may be associated with the therapeutic activity of TCM formulas. The correlation between TCM and diseases such as chronic liver disease, ulcerative colitis, obesity, and type 2 diabetes is highlighted, and future research is envisioned, ranging from experimental design to the disclosure of interactions between TCMs and the gut microbiota. A new concept for quality control named the “quality marker” is proposed by Professor Changxiao Liu and his colleagues, and is applied in a number of case studies. The principle of this new concept and approaches to practice it are expounded in depth. In order to elucidate the action mechanism of complex TCM systems, the term *chinmedomics* is defined by Professor Xijun Wang and his colleagues in the article entitled “Chinmedomics: A powerful approach integrating metabolomics with serum pharmacology to evaluate the efficacy of traditional Chinese medicine.” Dr. Werner Knoess, the former chairman of the Committee on Herbal Medicinal Products (HMPC) of the European Medicines Agency, describes the detailed requirements for the registration

of TCM products in the European Union, which serves as guidance for Chinese enterprises that may be interested in following this process. Safety and quality issues are also emphasized in two papers that focus on summarizing the pros and cons of these two important factors of medicine as a whole. Other aspects of TCM research are covered in the remaining papers, which include: TCM treatment for rheumatoid arthritis; an analysis of *Salvia* medicinal plants genomes; a DNA molecular marker to differentiate between plant species; micro- and nano-formulation to improve TCM bioavailability, tissue distribution, and efficacy; and an electro-acupuncture multicenter randomized controlled clinical trial, which clearly shows the movement of TCM toward becoming an evidence-based medicine.

The modernization and internationalization of TCM is a process that will take a considerable length of time; it requires the adoption of new technologies in diverse scientific fields and close cooperation among scholars in multiple disciplines. In the quest to decipher the myths of TCM theory and action mechanisms, all possible resources must be allocated in order to realize this goal, which will benefit the health of all humankind.