INTERVENTION OF GREEN NANOTECHNOLOGY TRANSFORMS AYURVEDIC MEDICINE INTO INTEGRATIVE GREEN NANOMEDICINE - A NEW VEDIC - ORIGIN MEDICAL PARADIGM FOR SAVING HUMAN LIVES GLOBALLY

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Article

Human productivity is intertwined with sustained good health of populations across the world. Indeed, state of mind is also directly connected with well-being of human population. Since the dawn of the 19th century, industrial revolution has provided numerous comforts in the form of automotives, telecommunications, information systems and lifesaving drugs to the human civilization. In the context of medicine, industrial revolution, with its roots from the western hemisphere, initiated the ubiquitous utility of chemicals in the development of various pharmaceuticals for human health and well-being. In this process, globally, we have ignored the importance of using plant-based herbal and sustainable medicine. We are now haunted with a 'State of Mind' unbale to find effective alternatives to the highly toxic chemical-based medicines. An important hallmark of the industrial revolution is that the moment we start our day, we start with putting chemicals in our mouth. **YES**, the toothpastes or the tooth powders we use are full of toxic chemicals. Many of these chemicals have been found to create various cancers and other diseases in humans. Yet, we have embraced this chemical-embedded life without investing in the discovery of safe and effective alternatives to toxic chemicals in medicine, cosmetics, food and many domains of human endeavors. There is no doubt that the chemical-based medicines, referred to as English or Western Medicines, are effective in treating various diseases symptomatically. Their long-term irreversible toxicity on the human body is being currently discussed extensively. A balance between herbal medicines from the holistic Ayurveda principles, and the Western medicine, has the potential to bring about the next medical revolution. To put things into perspective, it is important to consider historical perspectives of medicine.

Beginnings of Medicine on Planet Earth

There is a global consensus that the concept medicine on our planet was started in the Indian subcontinent around 800 BCE to 1000 CE when foundational medical practices were created. Indeed, Charaka-Samhita and Sushruta-Samhita, established the first ever rational scientific approach to medicine. Globally, plant-based medicines were practiced extensively until the 19th century. However, the start of the industrial revolution shifted medical treatment practices from plants/herbal medications to chemical-based formulations in various pharmaceuticals. As returns on investments into chemical-based medicines kept sky rocketing, more and more investments poured into establishing chemical-based pharmaceuticals, for the treatment of various diseases and disorders, as the universally accepted medical modality. Globally, over 90% of the population use chemical-based medications for the care and treatment for various illnesses. An important question is why did the medical practitioners, globally, embrace chemical-based pharmaceuticals? This is a highly relevant question because Atharvaveda, which thrived during the Vedic period of about 5000+ years ago, gave birth to the first ever medical modality Ayurveda. Ayurveda is considered as the beginning of holistic approach to health, incorporating herbal remedies, dietary practices, and spiritual elements for the care and well-being of human population. A recent study by the World Health Organization (WHO) has forecast that over 85% of the global population are interested in using plant-based herbal medicine for their care and well-being. However, the scientific rationale as well as the rigor and reproducibly of plant-based herbal medicines, in particular, Ayurvedic medicine has not flourished on par with the chemical-based Western medicine. Therefore, it is imperative to look into ways of embedding verifiable and universally acceptable scientific approaches toward validating Ayurvedic medicine—so that the global population will reap advantages of its unique strengths encompassing low/no toxicity, holistic whole body treatment approach and most importantly providing effective alternatives to the currently practiced Western medicine. This lecture provides a rational approach on how Green Nanotechnology can revolutionize Ayurvedic medicine for its transformation into a globally acceptable and clinically reliable medical modality.

Realms of Nanotechnology and Green Nanotechnology

Nanotechnology is the science and engineering of materials that are very tiny, generally in the range 1-100nm. Each nanometer is 10^{-9} meters, and it is this tiny size range that continues to unravel unprecedented chemical, physical, magnetic and electronic properties from various metals and non-metals. It is important to recognize that properties at the macro level which are not there will become available when macro sizes are transformed into nano sizes. For example, carefully engineered drug encapsulated gold nanoparticles, in the size range of 10-30 nm, can readily penetrate tumor cells which are in the 10–15-micron range—thus delivering therapeutic payload directly into tumor sites for effective cancer therapy. Most of the production processes currently used for the industrial large-scale production of nanoparticles utilize toxic chemicals. It is vitally important to minimize toxic chemicals in the production of nanomaterials because, at the nanoscale, toxic pollutants are invisible to the naked eye. This means that if we continue to accumulate stockpiles of industrial toxic waste from nanomaterials, they will cause near and long-term irreversible harm to living organisms on our planet. Green Nanotechnology is a process aimed at minimizing the utility of toxic chemicals in the production of various metallic and non-metallic nanomaterials. For example, the production of gold, silver or other metallic nanoparticles involves utility of toxic chemical reducing agents, to inject electrons into metals, to transform metallic precursors into their corresponding nanoparticles. Our discoveries in Green Nanotechnology are profound because we have utilized plants species as sources of electrons to transform metallic precursors into the corresponding nanoparticles as shown in **Figure 1**(1-10). The production processes as shown in Figure 1 have been scaled up to produce various types of nanoparticles at industrial scales through 'Zero Carbon' emission sustainable Green Nanotechnology. Myriads of nanoparticles produced through Green Nanotechnology have opened up new opportunities for their applications in medicine, electronics, food and agricultural applications. As the focus of my lecture is on the discovery of a new medical modality through Green Nanotechnology, subsequent discussions will entail details on the evolution of a new medical modality referred to 'Nano-Ayurvedic Medicine'—an approach for transforming Ayurvedic medicine into a highly effective and a reliable medical modality. Overall, our groundbreaking discoveries which have uncovered that various phytochemicals in plants serve as reservoirs of electrons, have opened up a new paradigm in medicine as discussed in the following sections (11-24).

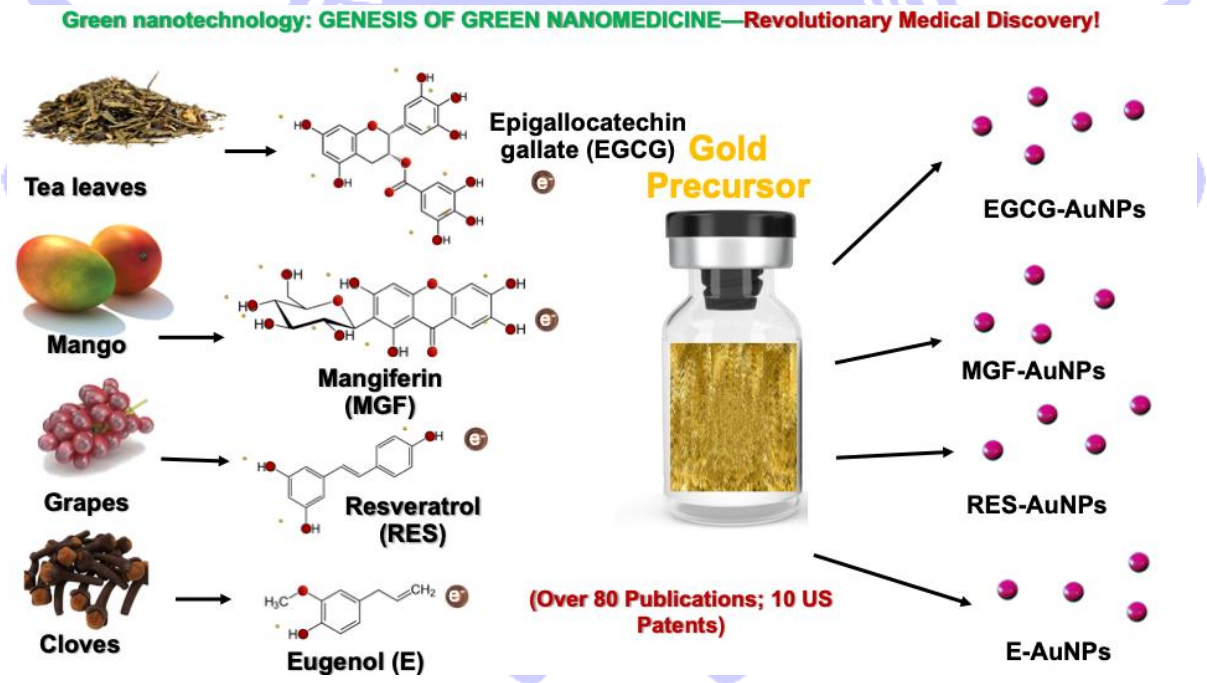

Figure 1: Green Nanotechnology harnesses electrons from Ayurvedically-relevant plants/herbs for the production of biocompatible Gold (and Silver) nanoparticles.

Serendipitous Connectivity of Green Nanotechnology to Ayurvedic Medicine—Discovery of 'Nano-Ayurvedic Medicine'—A New Integrative Medical Modality

Formulations of Ayurvedic medicines utilize cocktail of herbs along with various metals including gold, silver and copper. Our Green Nanotechnology approaches have injected verifiable scientific rigor demonstrating that electrons from various phytochemicals, upon interaction with metallic precursors, result in the production of a myriad of phytochemical-functionalized nanoceuticals (1-24). Our discoveries have uncovered that electron-rich phytochemicals such as Mangiferin (from Mango), Epigallocatechin gallate (EGCG) and a host of Ayurvedically-relevant herbal species serve the dual roles of transforming metals into well-defined gold (and silver)

nanoparticles, as well as those phytochemicals encapsulate nanoparticles surfaces effectively affording optimum in vitro and in vivo stability for various biomedical applications. Series of our investigations have revealed that incorporation of phytochemicals on nanoparticles surface, as shown in **Figures 2 and 3,** enhance their shelf life while imparting optimum bioavailability for treating various diseases.

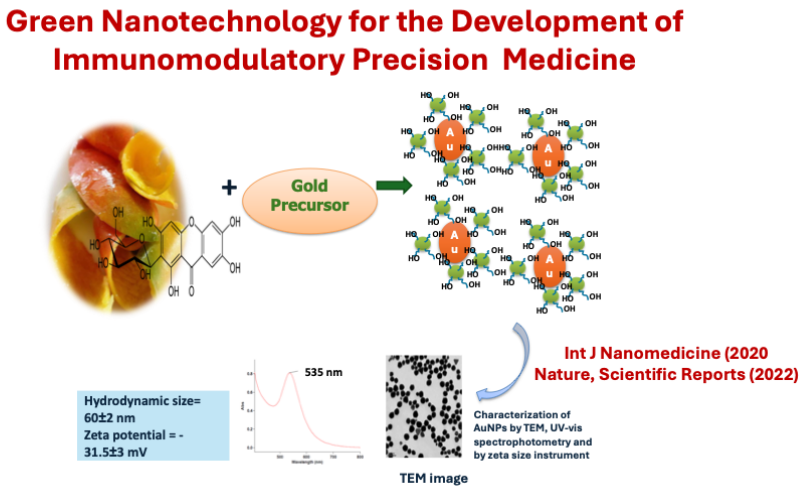

Figure 2: Green Nanotechnology allows self-assembly of medically-relevant phytochemicals on gold nanoparticulate surface—thus enhances stability and bioavailability.

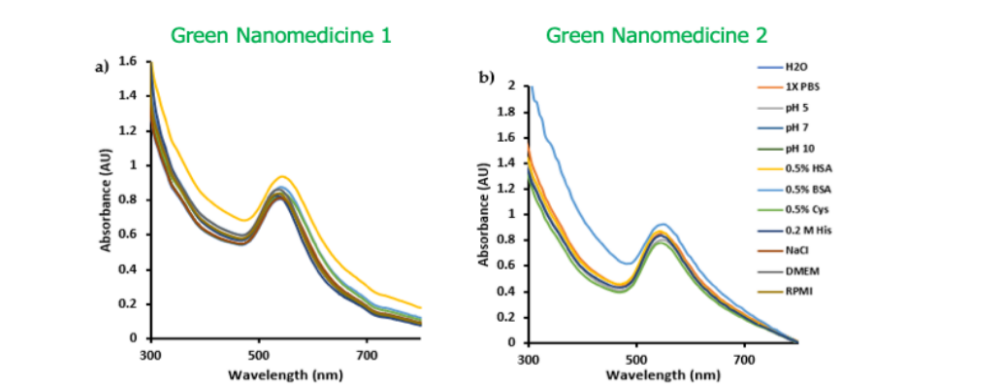

Figure 3: Incorporation of therapeutically useful phytochemicals on Gold Nano surfaces imparts optimum in vitro/in vivo stability as evidenced by stability in various biological fluids. Stability in the above figures assessed through Surface Plasmon Resonance (SPR)

Green Nanotechnology—An Unprecedented Scientific Rationale for Ayurvedic Medicine

Green Nanotechnology-based production pathways, as illustrated, in Figures 2 and 3, serendipitously follow the principles of Ayurveda—where cocktails of herbs mixed with certain types of minerals or metals have been practiced since the days of Charaka—the founder of Ayurveda. *Paradigm advantages brought about through Green Nanotechnology for enhancing the scope of Ayurveda as an Integrative Medical modality are summarized below:*

(i) Green Nanotechnology allows precise compositions of herbal cocktails with gold or silver precursors.

(ii) Green Nanotechnology-based formulations with Gold (and various other metal precursors) produces well-defined gold nanoparticles with encapsulation of Ayurvedically relevant phytochemicals on Gold nanoparticulate surface (Figures 1 and 2). The quantity of phytochemicals on gold nanoparticles surface as well as the precise size of gold nanoparticles can be measured through sophisticated scientific methods. This is a monumental scientific breakthrough which would transform Ayurveda as a precision therapeutic medical modality (as discussed in subsequent sections).

(iii) Collaborations with Kadamba company, Bengaluru, India, and the University of Missouri, Institute of Green Nanotechnology, within the Medical School, has resulted in the development of over 450 different formulations incorporating almost all herbal cocktails defined in Rasa Shastra to produce Swarna Rasayana and Rajata Rasayana for numerous therapeutic Integrative Green Nanomedicine applications.

(iv) Kadamba's Swarna Rasayana and Rajata Rasayana have received approval from AYUSH and are being produced in 100% reproducible cycles throughout the world.

(v) Most importantly, when the formulations are 100% reproducible, doses of these formulations for human administrations can be well-defined—thus allowing predictable clinical outcomes from human patients. This is an unprecedented outcome from our Green Nanotechnology approaches to Ayurveda.

We now have scientifically verifiable answers to the following important questions and amicable solutions to impediments that have haunted the widespread acceptability of Ayurveda globally:

- Traditional Ayurveda formulations lack reproducibility from batch to batch—thus doses for human administration have not been defined. This has impeded large scale productions of Ayurveda formulations at various global locations—thus contributing to painfully slow progress of this medical modality.

⇒ Our Green Nanotechnology approaches, as depicted in Figures 1 and 2, bear reproducible and rigorous scientific rationale. This means, Green Nanotechnology has helped overcome reproducibility problems associated with Ayurveda formulations that have haunted this medical field for centuries.

- Ayurveda formulations for Swarna Rasayana and Rajata Rasayana and allied Rasayanas lack precise scientific knowledge on the mechanism of action.

⇒ Our approaches of creating Nano Swarna Rasayana and Nano Rajata Rasayana (Figures 1-4), as discussed in the following sections, provide full details on the mechanisms of action for using these new generation of Nano-Ayurveda formulations for treating cancer and various other diseases including deadly bacterial and viral infections.

Nano Swarna Rasayana and Nano Rajata Rasayana—A Game Changing Green Nanotechnology Approach in Ayurveda

It has been postulated in several Ayurveda formulations, especially those that involve metals such as Gold, Silver and Cooper, that they contain nanoparticles of such metals. It has also been postulated that the biological activities of Ayurveda formulations are linked to their nanoparticulate formulations. However, a thorough scientific examination of commercially available Rasayanas of Gold, Silver and other metals has revealed that a vast majority of Ayurveda Bhasmas (and Rasayanas) contain less than 1-5% nanoparticles in their formulations. On the contrary, our discoveries which are focused on the production of Swarna Rasayana and Rajata Rasayana, through Green Nanotechnology, (Figures 1-4), produce nearly 99% of nanoparticles of gold (or silver) —thus making a scientifically compelling case to refer such Rasayanas as Nano Swarna Rasayana and Nano Rajata Rasayana respectively.

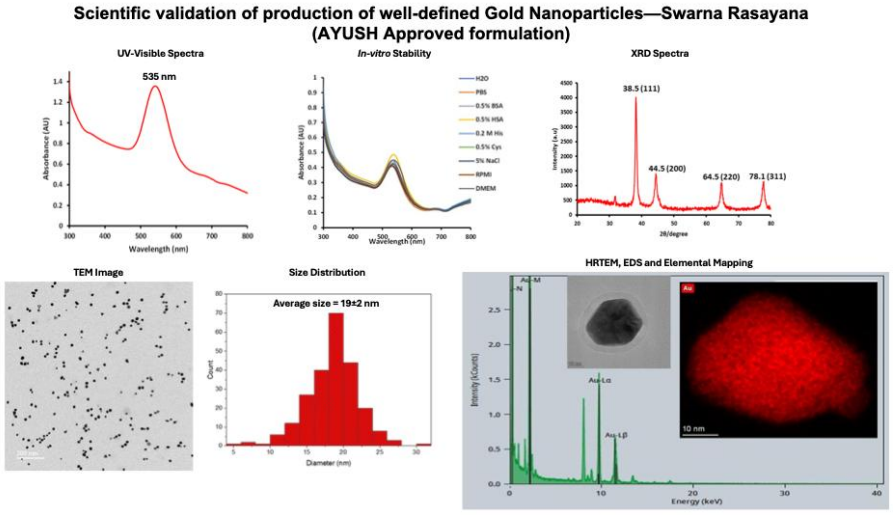

Figure 4: Green Nanotechnologies produce well-defined Gold Nanoparticles (Swarna Rasayana) Full characterization as shown in this Figure allows complete quality control of various therapeutic Green Nanomedicine formulations for clinical applications globally.

The following electron microscopic images (Figure 5) illustrate the importance of nano formulations of Ayurveda drugs in achieving biological effective doses for treating various diseases. Images in Figure 5 show that carefully engineered Nano Swarana Rasayana, in the size range of 15-30 nm, enter tumor cells effectively and site specifically—thus facilitating delivery of therapeutic cargo only to the tumor cells while sparing normal cells. This type of site selectivity has never been shown in Ayurveda formulations. Kadamba's approach to develop Nano Rasayanas, through Green Nanotechnology, may therefore be considered as a 'Game Changer' that is bound to revolutionize Ayurvedic medicine to benefit patient community.

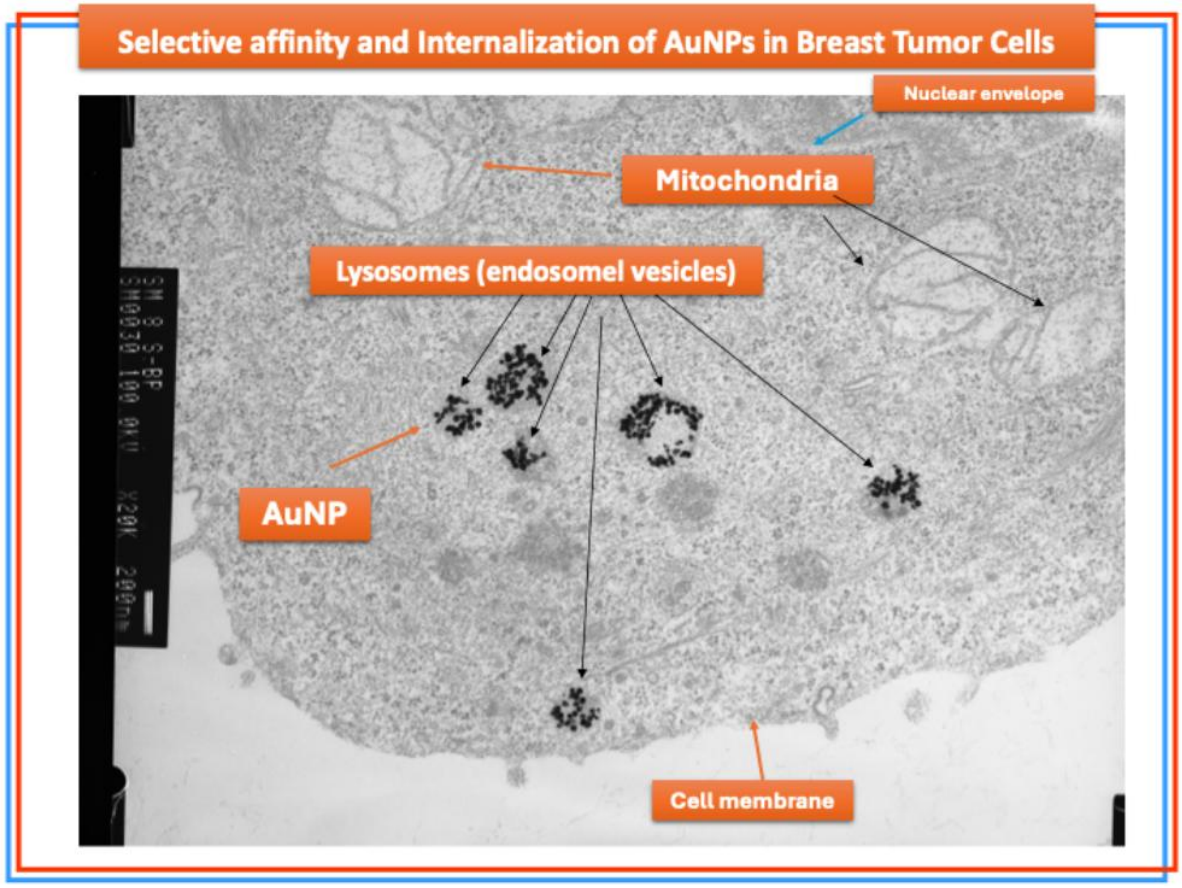

Figure 5: Phytochemicals functionalized Green Nanomedicines display selective affinity toward breast tumor cell receptors—thus delivering therapeutic payload for effective treatment

Creation of Green Nanomedicine - Symbiosis of Green Nanotechnology and Ayurveda

Western Medicine, commonly referred to as Allopathic medicine, has enjoyed hundreds of billions of dollars in investment toward research and development for over 100 years. This investment has helped carve out a niche and popularity of Western Medicine across the world. The scientific tools which include various in vitro and in vivo assays, use of sophisticated instrumentation and most importantly continuous hypothesis driven research—are the main contributors in transforming Western Medicine as a reliable medical modality with predictable clinical outcomes.

At Kadamba, through our ongoing collaborative efforts with the University of Missouri Medical School, we hypothesized the following:

Application of all the available sophisticated scientific tools, which are used in testing and validating Western Medicine, must be applied in validating Ayurvedic formulations. This is vitally important in understanding the mechanisms of treatment for various Ayurvedic formulations. It is important to utilize similar scientific tools, that are being used for validating Western Medicine, for gaining insights into mechanistic details of Ayurvedic medicine. Such scientific practices will provide rigorous and scientifically verifiable pathways for creating cross fertilizations between the Western Medicine and Ayurveda. Over the last 30 years, we have ventured into the application of various scientific tools from Western Medicine toward understanding mechanistic details embodying Ayurveda medical modality. This scientific activity has resulted in a new space that lies at the intersection of Western Medicine and Ayurveda and is referred to as Integrative Green Nanomedicine as shown in Figure 6.

Figure 6: Bridging Western Medicine with Ayurveda creates new Integrative Green Nanomedicine.

Our research efforts have demonstrated that Green Nanotechnology has the unprecedented power to bridge Ayurveda (and various eastern medical modalities) with the Western Medicine as shown in **Figure 6.**

KADAMBA's Bridge that Connects Ayurveda with Western Medicine is of Monumental Importance for the Future of Medicine:

Medical practice, throughout the world, has treated patients through a highly biased philosophy that 'One-Size-Fits-All'. Western Medicine has stood as a singular medical modality for treating various diseases and disorders throughout the world. Neither the medical doctors nor the patients have enjoyed the possibility of various choices in treating diseases and disorders. The most recent COVID-19 pandemic has demonstrated the spectacular failure of 'One-Size-Fits-All' philosophy being practiced in medicine. Despite all the innovations and stunning discoveries in medicine, spanning over 100 years, we witnessed deaths of over 7,089,976 human patients due to COVID-19 pandemic that swept this planet (24). Western Medicine was the only tool that was made available for treating patients infected with COVID-19 throughout the world. Common sense tells everyone that choice brings new opportunities, choices bring more hope and enhanced success. We saw a complete absence of choices of medical treatments from Ayurveda or other medical modalities for saving lives of human patients. Clearly, 'One-Size-Fits-All' has failed. In fact, there are numerous diseases and disorders, from cancers, deadly viral/bacterial infections to neurological diseases—where it is well-known that Western Medicines have failed to provide curative benefits to debilitating patients. This is where the importance of creating a scientific bridge, that harnesses the powers of the rigor and the ultra-modern scientific innovations of Western Medicine, with the holistic and whole-body treatment approaches of Ayurveda would benefit patient community immensely.

The following sections will provide details on various treatment approaches we have developed through our continued collaborative endeavors between Kadamba, Bengaluru and with the Institute of Green Nanotechnology, University of Missouri Medical School, Columbia, Missouri, USA.

Immunomodulatory Green Nanomedicine:

The real power of Ayurvedic medicine stems from its powerful philosophy, centered on conditioning the entire human body (whole body treatment), for dealing with various diseases or disorders rather than symptomatically treating specific organs. Ayurvedic modality derives its strengths as a whole-body treatment approach rather than 'One-Organ-One-Treatment' philosophy which is the bedrock of the Western medicine symptomatic treatment philosophy. Ayurvedic medicine is all about giving the human body the strength needed to fight and treat the disease. In the Western medical modality such types of treatments are often called as 'immunomodulatory Treatment'. Immunomodulatory approaches are based on upregulation of certain types of cytokines, such as IL-12, and down regulation of cytokines such as IL-10. In the context of inflammatory diseases such as human cancers, diabetes or arthritis, immunomodulatory drugs that upregulate IL-12 cytokines, and down regulate IL-10 cytokines play vital roles in immunomodulation for treatments. Although, Ayurveda treatments have origins of

immunomodulation, lack of acceptable scientific mechanisms as well as limited scientific evidence on quantitative assessment of immunomodulatory biomarkers has resulted in limited acceptability of Ayurveda as a reliable immunomodulatory medical modality.

We have performed extensive research on the immunomodulatory characteristics of our Integrative Green Nanomedicines (Figure 7). We have shown that Kadamba's iconic Swarna Rasayana Integrative Green Nanomedicine, upon treatment with cancer cells, results in a highly significant elevation of IL-12 cytokine. IL-12 cytokine is a pro-inflammatory cytokine which plays a crucial role in driving T helper (Th) cells which provide helper functions to other cells of the immune system—especially the antigen-presenting cells (APCs) such as macrophages, dendritic cells, and B cells—and are important for their activation and maturation. IL-12 cytokine promotes the anti-tumor and immune system boosting M1 macrophage polarization, which is associated with an anti-tumor immune response. M1 macrophages are classically activated and secrete pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β, which help in tumor suppression.

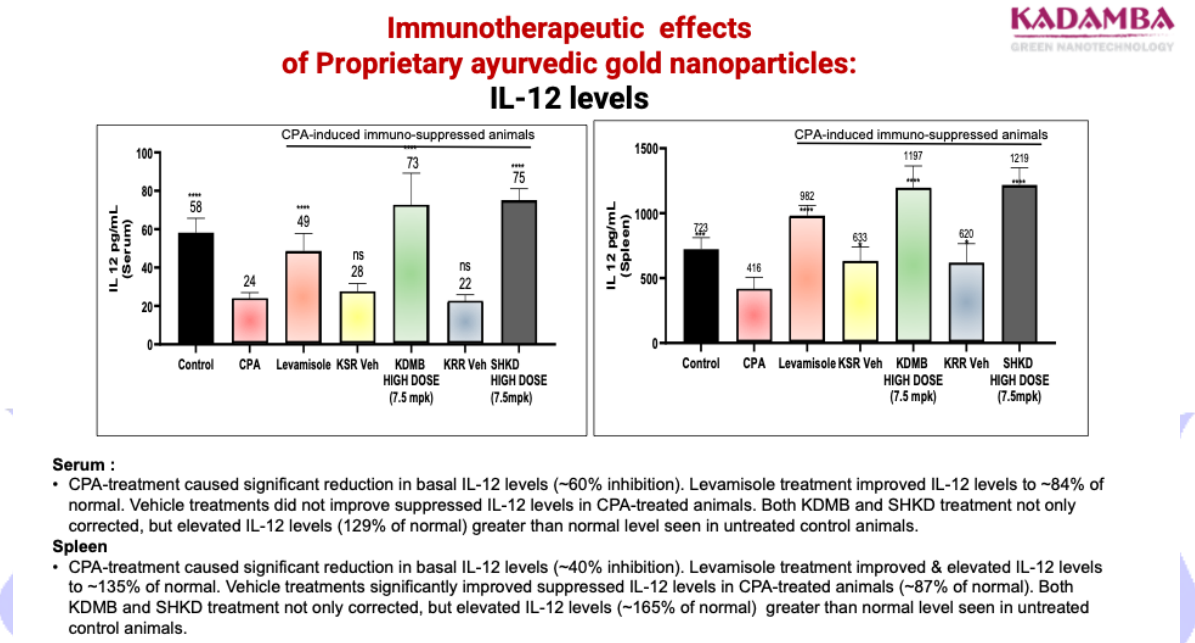

Figure 7: Immunomodulatory characteristics of phytochemical functionalized Gold Nanoparticle Green Integrative Nanomedicine formulations

Results of interactions of Kadamba's Swarna Rasayana (Integrative Green Nanomedicines) with various types of tumor cells as well as pro tumor macrophages have revealed significant increases in IL-12 expression, which drives anti-tumor M1 macrophage polarization and cytotoxic T-cell responses (Figure 7). When combined with IL-12, IL-6 can contribute to an inflammatory environment that helps recruit NK cells and CD8+ T cells to attack tumor cells.

From Bench to Bed:

(a) **Treatment of Cancers:** Upon AYUSH approval of Kadamba's Green Nanomedicine products, medical doctors have treated thousands of patients with debilitating cancers. Results from treating human patients with triple negative breast cancers are shown in **Figure 8.** These results show that Kadamba's Integrative Green Nanomedicines treat triple negative breast cancers with unprecedented clinical success. The immunomodulatory characteristics of Kadamba's Integrative Green Nanomedicines have benefited in saving lives of thousands of human patients with advanced prostate, pancreatic, lung and various life-threatening cancer conditions across the world.

(b) **Treatment of Deadly Infections:** Kadamba's Rajata Rasayanas have shown excellent efficacy in treating infections from gram+ and gram– bacteria. Kadamba's Rajata Rasayana has also shown excellent clinical efficacy in treating patients with viral infections such as AIDS as well as COVID-19 infections. In fact, during the latest COVID pandemic, thousands of patients were treated with Kadamba's Rajata Rasayana with 100% curative results.

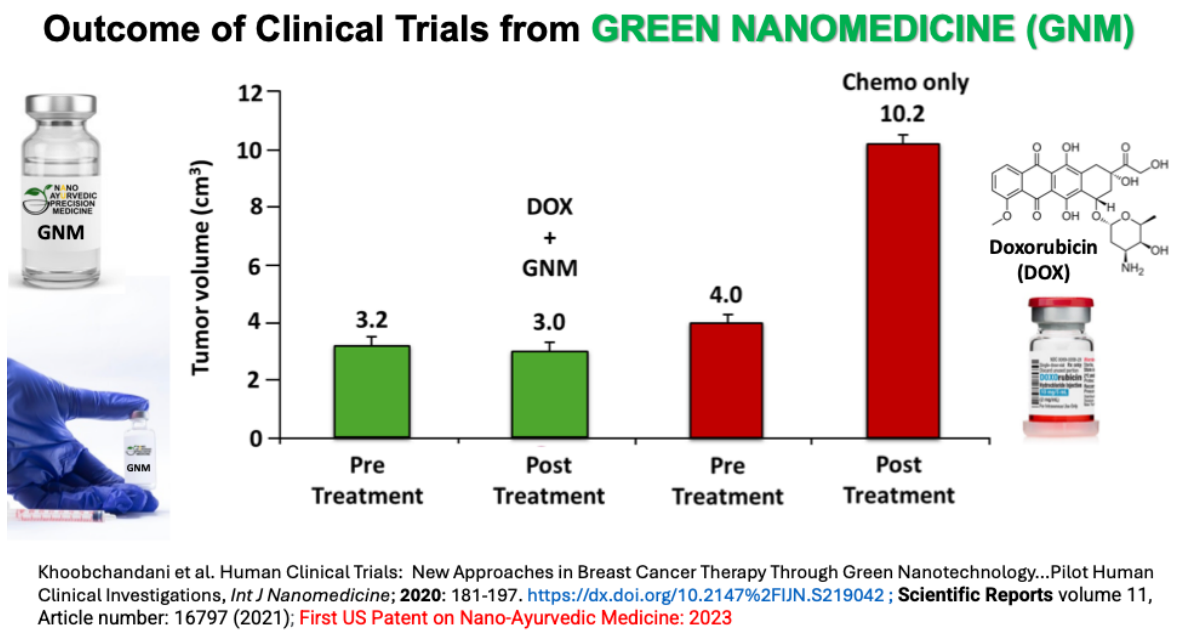

Figure 8: Therapeutic efficacy data showing effective treatment of triple negative breast cancer patients with Kadamba's Integrative Green Nanomedicines

Concluding Remarks

Scope of science is limitless. Science alone is a wheelless chariot or a wheelless electric vehicle. Science requires human civilization to run and fly. Humans have also used science for destruction purposes both rationally and irrationally. We have not witnessed the tremendous breadth and width, and the tremendous scientific power of what mother nature can offer to medicine. Our research efforts have shown that Green Nanotechnology, which uses plants, trees, flowers, roots and leaves—as sources of electrons—is a remarkable tool to revolutionize medicine. The results discussed, herein, unequivocally provide compelling scientific rationale for the genesis of Integrative Green Nanomedicine (or Nano-Ayurvedic medicine) to be the new frontier in India's/Global next medical revolution.

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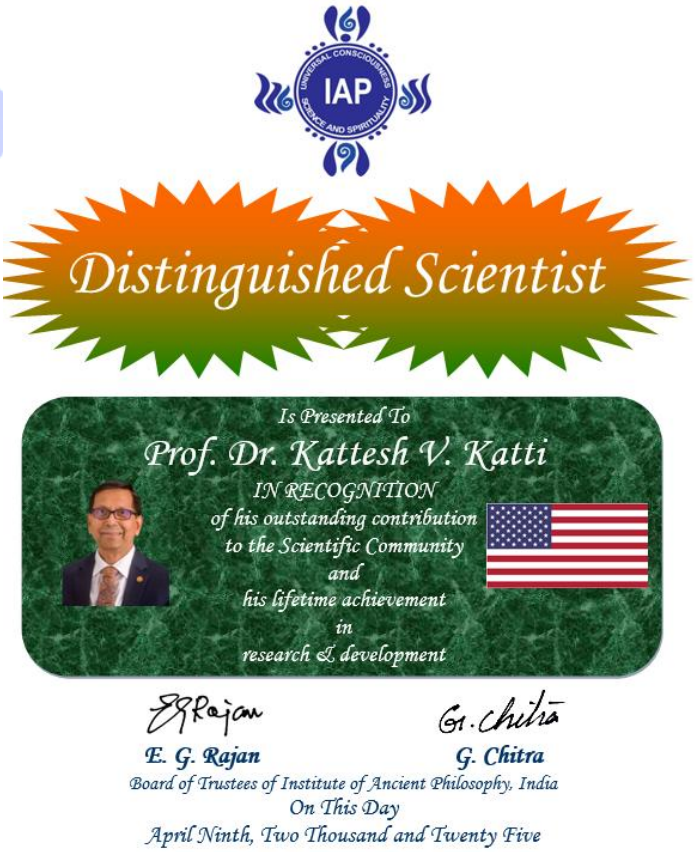
About the Author

Kattesh V. Katti, M.Sc.Ed, PhD, DSC, FRSC, FNAI, FAIMB is Globally recognized as the 'Father of Green Nanotechnology', Prof. Katti is Curators' Professor of Radiology, Director, Institute of Green Nanotechnology, within the Medical School, University of Missouri, Columbia, USA. He is internationally renowned as a leader in the interconnecting fields of chemistry, Materials science, radiopharmaceutical sciences, nanotechnology/green nanotechnology and nanomedicine for biomedical applications, specifically for molecular imaging and therapy of living subjects. Dr. Katti is a pioneer in the field of Nano-Ayurvedic Medicine, a new medical modality which he has discovered by the application of Nuclear Analytical, Radiochemical techniques and Green Nanotechnology to Ayurvedic - Holistic Medicine. In 2024, the US/European Union Patents and Trademarks office has granted the first ever US patent on Dr. Katti's discovery of a new medical modality referred to as 'Nano-Ayurvedic Medicine' Several cancer therapy products and antibiotics, discovered by Dr. Katti, are currently used in treating human patients. For his groundbreaking discoveries in SPECT/PET imaging and radiopharmaceuticals sciences, Dr. Katti has won the International Hevesy Medal Award, a Global award for excellence in Nuclear Medicine regarded as equivalent to a Nobel Prize in Nuclear Sciences. Dr. Katti's groundbreaking research in Green Nanotechnology has direct implications in a myriad of fields including Health Care, Cosmeceuticals, Adaptative Clothing, Food Functioning and Nanofoods and allied sectors of human domain. For his global recognitions in these fields, he has been seminally elected by numerous prestigious academies of the world including: Elected fellow of the American Institute of Medicine and Biological Engineering; Elected fellow of the American Association for the Advancement of Science; Elected fellow of the National Academy of Inventors; and Elected fellow of the Academy of Science, St Louis, one of the oldest scientific academies of the world. in Popular Science, and by the Discovery Channel. and in the scientific/medical programs of the British Broadcasting Company (BBC), Discovery Channel and the Voice of America. Dr. Katti has published over 300 publications, reviews, and book chapters and is the principal inventor on over 150 inventions and over 50 patents. He has delivered over 500 Inaugural/Plenary/Invited lectures in 25 countries. Dr. Katti is the chief editor, editorial board member or member of advisory boards of several internationally reputed peer reviewed scientific journals.



Prof. Dr. Kattesh Katti has been honored with the title of "Distinguished Scientist on April 12, 2025