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**THE GREAT PHYSIOLOGIST**  
**ARTHUR CLIFTON GUYTON**

**ВИДАТНИЙ ФІЗІОЛОГ АРТУР**  
**КЛІФТОН ГАЙТОН**

**Ключевые слова:** профессор Артур Клифтон Гайтон, физиология, медицина.

**Роман Л., Тимофійчук І. Выдающийся физиолог Артур Клифтон Гайтон.**

В статье исследуются основные этапы жизненного и творческого путей, а также важные научные достижения в области физиологии одного из самых выдающихся физиологов мира – профессора Артура Клифтона Гайтона.

Именно А. Гайтон первым внес значительный вклад в понимание этиологии гипертонии и стал автором учебника по физиологии, который был затребован во всех медицинских университетах в течении 45 лет, выдержал 11 переизданий и был переведен на 15 языков.

Professor Arthur Clifton Guyton has been considered a major force in physiology, not only in the United States, but in the world. He was the author of the world's most widely used medical textbooks, a researcher who made significant contributions to the understanding of hypertension and who was the father of 10 Harvard-educated doctors<sup>1</sup>. Dr. Guyton was born in Oxford, Mississippi, to a family of Dr. William S. Guyton, an ophthalmologist and dean of the University of Mississippi medical school, and Kate S. Guyton, a math and physics teacher who had been a missionary in China before their marriage.

He graduated from high school with honors and was top in his class at the University of Mississippi. At Harvard Medical School his ideas about measuring and differentiating ions in a solution so impressed a biophysics professor that Guyton was given his own small lab.

Guyton's surgical internship at Massachusetts General Hospital was interrupted by World War II. He served in the Navy at the National Naval Medical Center in Bethesda and later at Camp Detrick in Maryland, earning an Army Commendation Citation. Returning to Massachusetts General to finish his residency, Guyton was stricken with polio. The disease left his right leg and shoulder paralyzed, but that didn't slow him down.

During his recuperation Guyton designed a leg brace, a hoist for lifting patients and a motorized wheelchair. His enthusiasm for building machines he needed became his trademark.

Guyton returned to Oxford in 1947, joining the faculty at the university's School of Medicine. He struck up a friendship with neighbor William Faulkner and taught the author how to sail and to play chess. In 1948 Guyton was appointed professor and chairman of the Department

of Physiology and Biophysics, positions he held until his retirement in 1989.

In the 1950s Guyton, whom most students called "The Chief," starting filling in the information void surrounding heart and blood vessel functions. His first major discovery rewrote contemporary wisdom that the heart controlled cardiac output. His "permissive heart" concept showed that body tissues' need for oxygen determined cardiac output. He next succeeded in measuring the pressure of the interstitial fluid between the cells, something no one had been able to do. In 1966 he used an early computer model to develop the theory of "infinite gain," which gave the kidneys preeminence as the most important regulator of blood pressure.

Over the course of his career Guyton published hundreds of papers and wrote scores of books. His "Textbook of Medical Physiology"<sup>2</sup> has been a requirement in medical schools worldwide for the past 45 years. Guyton was working on the 11<sup>th</sup> edition at the time of his death. He published his Textbook of Medical Physiology in 1956. Based on his classroom lectures, it provides one of the foundations of medical education and explains in detail the functioning of the organs. One of the rare medical books written by one author, it is now in its 10th edition and has been translated into 15 languages. Recent editions have been updated by his former student and successor as chairman of the physiology department at the University of Mississippi Medical Center, Dr. John E. Hall.

Dr. Guyton's research contributions, which include more than 600 papers and 40 books, are legendary and place him among the greatest figures in the history of cardiovascular research. His research covered virtually all areas of cardiovascular regulation and led to many

seminal concepts that are now an integral part of our understanding cardiovascular physiology and disorders such as hypertension, heart failure, and edema. It is difficult to discuss cardiovascular regulation without including his concepts of cardiac output and venous return, negative interstitial fluid pressure and regulation of tissue fluid volume and edema, regulation of tissue blood flow and whole body blood flow autoregulation, renal-pressure natriuresis and long-term blood pressure regulation<sup>3</sup>.

Perhaps his most important scientific contribution, however, was his unique quantitative approach to cardiovascular regulation through the application of principles of engineering and systems analysis. He had an extremely analytical mind and an uncanny ability to integrate bits and pieces of information, not only from his own research but also from that of others, into a quantitative conceptual framework. He built analog computers and pioneered the application of large-scale systems analyses to modeling the cardiovascular system before digital computers were available. With the advent of digital computers, his cardiovascular models expanded dramatically in the 1960s and 1970s to include the kidneys and body fluids, hormones, and autonomic nervous system, as well as cardiac and circulatory functions.

He provided the first comprehensive systems analysis of blood pressure regulation and used this same quantitative approach in all areas of his research, leading to new insights that are now part of the everyday vocabulary of hypertension researchers. Dr Guyton's far-reaching concepts have been, and will continue to be, the foundation for generations of cardiovascular and hypertension researchers<sup>4</sup>.

Dr Guyton received more than 80 major honors from diverse scientific and civic organizations and universities throughout the world. A few of these that are especially relevant to cardiovascular and hypertension research include the Ciba Award from the Council for High Blood Pressure Research, the William Harvey Award from the American Society of Hypertension, the Research Achievement Award of the American Heart Association, the Merck, Sharp, and Dohme Award of the International Society of Hypertension, and the Wiggers Award of the American Physiological Society. It was appropriate that in 1978 he was invited by the Royal College of Physicians in London to deliver a special lecture honoring the 400th anniversary of the birth of William Harvey who discovered the circulation of the blood.

Although Dr. Guyton's research accomplishments are legendary. The fact that he and Ruth raised 10 remarkable children, all of whom became outstanding physicians, is a great educational achievement in itself. Eight of the Guyton children graduated from Harvard Medical School, one from Duke Medical School, and one from the University of Miami Medical School after receiving a PhD from Harvard.

The success of the Guyton children did not occur by chance. Dr Guyton's philosophy of education was to "learn by doing." The children therefore participated in countless family projects that included the design and construction of their home and heating system, swimming pool, tennis court, sailboats, homemade go-carts and electrical cars, gadgets for their home, and electronic

instruments for their Oxford Instruments Company. Television programs such as "Good Morning America" and "20/20" described the remarkable home environment that Arthur and Ruth Guyton created to raise their family. They are a wonderful family, sharing the values of hard work and dedication, teamwork, the excitement of learning and discovery, and a deep love for each other. His devotion to family is beautifully expressed in his "Textbook of Medical Physiology" that bears this dedication: "To My Father for his uncompromising principles that guided my life; My Mother for leading her children into intellectual pursuits; My Wife for her magnificent devotion to her family; My Children for making everything worthwhile."

Dr Guyton was a master teacher and personally taught every medical student at the University of Mississippi for over 50 years. Even though he was always busy with service responsibilities, research, writing, and teaching, Dr Guyton was never too busy to talk about a new research idea or a new experiment or to talk with a student who was having difficulty. He would never accept an invitation to give a prestigious lecture if it conflicted with his teaching schedule.

His contributions to education are also far reaching through generations of graduate students and postdoctoral fellows. He trained over 150 scientists, of whom at least 29 became chairs of their own departments and 6 became presidents of the American Physiological Society. He gave students confidence in their own abilities and emphasized his belief that "People who are really successful in the research world are self-taught because they are teaching themselves beyond where other people are." No one has been more prolific in training leaders of physiology than Arthur Guyton. For his many contributions to medical education, Dr Guyton received the 1996 Abraham Flexner Award from the Association of American Medical Colleges. He is also honored each year by the American Physiological Society through the Arthur C. Guyton Teaching Award. In 2001, he received the Eugene Braunwald Academic Mentorship Award from the American Heart Association.

As we already said, Guyton was the father of 10 children, all of whom are physicians. Dr. Guyton had a family life that was every bit as busy as his professional one. A 1982 article in Reader's Digest, "A Doctor Who's Dad to Seven Doctors -- So Far!",<sup>5</sup> described the many family projects that he led, including the design and construction of the family's house and swimming pool.

When asked why all of the Guyton children had decided to go into medicine, David, the eldest, said, "Daddy never lectured us about medicine: He stimulated our interest." Thomas, the ninth child, said, "He instilled the work ethic in all of us, but I think I learned most from his disability". There were, of course, other motivating factors. In a 1993 article in Harvard Magazine celebrating his father's 50th reunion and the graduation of his youngest sibling from medical school, Douglas, the seventh child, admitted: "The pressure on me was intense. I can only imagine what it must have been like for the three youngest".

The Guyton children are David, of Baltimore; Robert, of Atlanta; John, of Durham, N.C.; Steven, of Seattle;

Catherine Greenberger of Sewickley, Pa.; Jean Gispén of Oxford, Miss.; Douglas, of Reno; James, of Memphis; Thomas, of Memphis; and Gregory, of Baltimore. They are spread across eight states, from Pennsylvania to Georgia to Washington. These MDs represent a variety of medical specialties, from ophthalmology to rheumatology.

"There are almost enough specialties to staff a small hospital. I guess if you could get everyone in the same location," said Cathy Greenberger, MD, one of the sisters.

The young men all received their medical degrees from Harvard; Catherine Greenberger received hers from the University of Miami after earning a bachelor's and doctorate in organic chemistry from Harvard, and Jean Gispén graduated from the Duke University medical school after finishing her undergraduate work at Harvard. The Guyton physicians are scattered across the country and across medical specialties. David Guyton, MD, professor of pediatric ophthalmology, Johns Hopkins University School of Medicine, Baltimore. Robert Guyton, MD, professor of surgery and chief of the cardiothoracic division, Emory University, School of Medicine, Atlanta. John Guyton, MD, associate professor of medicine, Duke University, North Carolina. Steven Guyton, MD, cardiothoracic surgeon at Virginia Mason Medical Center, Seattle. Cathy Greenberger, MD, former internist in Boston, now lives in Pittsburgh. Jean Gispén, MD, rheumatologist, Oxford, Miss. Douglas Guyton, MD, anesthesiologist, Reno, Nev. James Guyton, MD, orthopedic surgeon, Campbell's Clinic, Memphis, Tenn. Thomas Guyton, MD, anesthesiologist in Memphis. Gregory Guyton, MD, orthopedic surgeon and assistant professor, University of North Carolina at Chapel Hill. Dr. Guyton is also survived by a sister, Ruth Smith of Frederick, Md.; a brother, William, of Austin, Tex.; 32 grandchildren; and 2 great-grandchildren.

Dr Guyton's accomplishments extended far beyond science, medicine, and education. He was an inspiring role model for life as well as for science. Dr Guyton taught students much more than physiology - he taught their life, not so much by what he said, but by his unspoken courage and dedication to the highest standards.

He had a special ability to inspire people through his indomitable spirit. Although he was severely crippled with polio, no one who ever worked with Arthur Guyton thought of him as being handicapped. His brilliant mind, his indefatigable devotion to science, education, and family, and his spirit and courage captivated students and trainees, professional colleagues, politicians, business leaders, and virtually everyone who knew him.

Those who did not know him well were often curious about how he accomplished so much despite his "handicaps." Elvin Smith, one of Dr Guyton's students, who later became chair of physiology and executive vice president of the medical school at Texas A&M, tells a story about the time Dr Guyton took him and other members of the department to attend a banquet at which Dr Guyton and Eudora Welty (who won a Pulitzer Prize for fiction among many other honors) received the first Outstanding Mississippian Award. After the ceremony, the

students were standing next to Dr Guyton as he was being congratulated. One of the ladies in the line stopped to talk to Elvin and to Jack Crowell, a faculty member and former student, and asked "Isn't it amazing what Dr Guyton has accomplished with his handicaps?" With little hesitation, Jack looked up and said, "Yes ma'am, it sure is amazing, and Elvin and I are two of his biggest handicaps." Those people who worked with Dr. Guyton never thought of him as handicapped. They were too busy trying to keep up with him.

Dr Guyton's courage in the face of adversity humbled everyone. He would not succumb to the crippling effects of polio. He and his children not only built their home but also repaired each and every malfunctioning appliance and home device no matter the difficulty or the physical challenge.

Dr. Guyton received many honors, including awards from the American Medical Association, the American Heart Association and medical organizations in Russia, Japan and the Netherlands. He told Harvard Magazine that one held special meaning for him: the 1978 invitation from the Royal College of Physicians in London to deliver a lecture honoring the 400th anniversary of the birth of William Harvey, the doctor who first described the circulation of blood.

Dr. Arthur C. Guyton died in an automobile accident near his home in Jackson, Miss., on April 3, 2003. He was 83. He gave to the scientific world an imaginative and innovative approach to research and many new scientific concepts of cardiovascular regulation, he gave countless students throughout the world a means of understanding physiology, he gave many of us exciting research careers, and most of all, he inspired all - with his devotion to education, his unique ability to bring out the best in those around him, his warm and generous spirit, and his courage. Dr Arthur Guyton was a real hero to the world, and his legacy is everlasting.

## References:

- 1 Brinson C, Quinn J. Arthur C. Guyton: His Life, His Family, His Achievements. Jackson, Miss: Hederman Brothers Press. - 1989. - P. 23-89.
- 2 Guyton AC. Textbook of Medical Physiology. - Philadelphia, Penn: W.B. Saunders Co, 1956. - 675 p.
- 3 Guyton A. C, Coleman T. G, Granger H. J. Circulation: Overall regulation. - *Annu Rev Physiol.* - 1972; 34. - P. 13-46.
- 4 Guyton A. C, Coleman T. G. Quantitative analysis of the pathophysiology of hypertension. - *Circ Res.*, 1969; 24 (suppl I). - P.1-19.
- 5 Bode R. A doctor who's dad to seven doctors - so far! // *Reader's Digest.* - December, 1982. - P. 141-145.

**Роман Л., Тимофійчук І. Видатний фізіолог Артур Кліфтон Гайтон.** У статті досліджуються життєвий та науковий шлях професора Артура Кліфтона Гайтона, якого було визнано основною рушійною силою в фізіології не тільки в Сполучених Штатах, але і в цілому світі. Він був автором навчального підручника з фізіології, який витримав 11 перевидань і був перекладений на 15 мов. Саме А. Гайтон першим зробив значний внесок у розуміння етіології гіпертонії.

Артур Кліфтон Гайтон народився в 1919 році в Оксфорді, штат Міссісіпі, в сім'ї лікаря Вільяма С. Гайтона – офтальмолога і декана медичного університету Міссісіпі, і Кейт С. Гайтон – вчительки математики та фізики, яка до заміжжя була місіонеркою в Китаї.

Хірургічне стажування А. Гайтона в Массачусетському госпіталі було перерване Другою світовою війною. Під час війни він служив на флоті в Національному військово-морському медичному центрі в Бетесді, а потім в таборі Детрике в Меріленді. Повернувшись до Массачусетського госпіталю, щоб закінчити своє стажування, А. Гайтон захворів на поліомієліт. Згодом внаслідок хвороби його права нога і плече були паралізовані, але це не зупинило його на шляху до успіху. А. Гайтон був дуже цілеспрямованою людиною.

Після тривалого лікування в 1947 році він повертається до Оксфорду і працює в медичному університеті. Вже у 1948 році А. Гайтона було призначено професором і завідувачем кафедри фізіології і біофізики. Цю посаду він займав понад 40 років - до 1989 року, коли професор вийшов на пенсію.

У 1950-ті роки А. Гайтону вдалося виміряти тиск інтерстиціальної рідини між клітинами, що до нього не вдавалося зробити нікому. Вже у 1966 році він використовував ранню комп'ютерну модель, щоб розвинути теорію «нескінченного посилення», яка дала змогу довести, що нерви посідають перше місце в регуляції кров'яного тиску.

Впродовж своєї кар'єри професор А. Гайтон опублікував сотні статей і написав десятки книг. Він одноосібно написав та видав «Підручник з медичної фізіології», який витримав 11-ть перевидань, що свідчить про його наукову актуальність та цінність. Уперше автор опублікував свій підручник з медичної фізіології ще в 1956р. Читкість та доступність викладу складного наукового матеріалу щодо функціонування всіх органів людського тіла стали причиною того, що підручник був затребуваний в медичних школах по всьому світу протягом останніх 45 років і в зв'язку з цим був перекладений на 15 мов.

Впродовж свого тривалого наукового життя професор А. Гайтон отримав багато нагород, в тому числі нагороди від Американської медичної асоціації, Американської асоціації серця і медичних організацій в Росії, Японії та Нідерландів, але свого часу він сказав, що саме Гарвардський Журнал мав для нього особливе значення, тому що в 1978 році він отримав запрошення від Королівського коледжу лікарів в Лондоні, щоб прочитати лекцію в честь 400-річчя від дня народження Вільяма Харві, лікаря, який вперше описав циркуляцію крові.

Професор Артур Гайтон загинув в автомобільній аварії недалеко від свого будинку в місті Джексон, штат Міссісіпі, 3 квітня 2003р. Йому був 83 роки. А. Гайтон дав науковому світу творчий та інноваційний підхід до дослідження і багато нових наукових концепцій серцево-судинної системи регулювання, він дав незліченну кількість студентів по всьому світу, новий погляд та розуміння фізіології, він дав багатьом захоплюючі наукові кар'єри, і, найбільше, він надихнув всіх його відданістю до творення, його унікальною здатністю виявляти краще в оточуючих його людях. Його 10 дітей, які стали лікарями, гідно продовжують шлях свого батька.

**Ключові слова:** Артур Кліфтон Гайтон, фізіологія, медицина.

**Роман Лілія** – кандидат філологічних наук, викладач кафедри суспільних наук та українознавства ВДНЗ України «Буковинський державний медичний університет». Автор понад 60 публіцистичних та 32 наукових і навчально-методичних робіт. Співавтор навчально-методичного підручника та монографії. Коло наукових інтересів: інновації у методиці викладання української мови як іноземної, порівняльна граматики та стилістика української та англійської мов, нейролінгвістика, психолінгвістика.

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