Journal of Medical Bacteriology

Nobel Prizes in Physiology or Medicine with an Emphasis on Bacteriology

Hamid Hakimi [1], Ebrahim Rezazadeh Zarandi [1], Siavash Assar [2], Omid Rezahosseini [3], Sepideh Assar [4], Roya Sadr-Mohammadi [5], Sahar Assar [6], Shokrollah Assar [7]*

[1] *Department of Microbiology, Medical School, Rafsanjan University of Medical Sciences, Rafsanjan, Iran.*

[2] *Department of Anesthesiology, Medical School, Kerman University of Medical Sciences, Kerman, Iran.*

[3] *Department of Infectious and Tropical Diseases, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran.*

[4] *Department of Pathology, Dental School, Shiraz University of Medical Sciences, Shiraz, Iran.*

[5] *Dental School, Rafsanjan University of Medical Sciences, Rafsanjan, Iran.*

[6] *Dental School, Shiraz University of Medical Sciences, Shiraz, Iran.*

[7] *Department of Microbiology and Immunology of Infectious Diseases Research Center, Research Institute of Basic Medical Sciences, Rafsanjan University of Medical Sciences, Rafsanjan, Iran.*

ARTICLE INFO

Article type:
Review Article

Article history:
Received: 02 Feb 2019
Revised: 28 Mar 2019
Accepted: 06 May 2019
Published: 13 Jun 2019

Keywords:
Medical Bacteriology, Medicine, Nobel Prize.

ABSTRACT

Background: Knowledge is an ocean without bound or shore, the seeker of knowledge is (like) the diver in those seas. Even if his life is a thousand years, he will never stop searching. This is the result of reflection in the book of development. Human beings are free and, to some extent, have the right to choose, on the other hand, they are spiritually oriented and innovative, and for this reason, the new discovery and creativity are felt. This characteristic, which is in the nature of human beings, can be a motive for the revision of life and its tools and products. It has made life, an effort to change the status quo so that it can be employing and utilizing intelligence, wisdom, deception, beauty, and choice. So, innovation, advancement, while discovering and identifying pathogenic bacteria and ways to control them, is very amazing. The era of bacterial infections can be divided into three periods; the era of the discovery, use of antibiotics and the era of the emergence of antibiotic resistance, which seems to be it is in the transition from the second to the third period.

***Conclusion*:** So far, there are nine microbiologists that have been awarded the Nobel Prize in the field of medical Bacteriology. Therefore it is the time to identify bacterial products and their partial functions to use in a variety of areas, especially in controlling new and/or emerging infectious diseases and provide a fairly comfortable future for our next generations.

- ***Please cite this paper as:*** Hakimi H, Rezazadeh Zarandi E, Assar SI, Rezahosseini O, Assar SE, Sadr-Mohammadi R, Assar SA, Assar SH. Nobel Prizes in Physiology or Medicine with an Emphasis on Bacteriology. *J Med Bacteriol.* 2019; **8** (3, 4): pp.49-57.

*Corresponding Authors: Shokrollah Assar, Department of Microbiology and Immunology of Infectious Diseases Research Center, Research Institute of Basic Medical Sciences, Rafsanjan University of Medical Sciences, Rafsanjan, Iran. *Tel*: +98-34-31315021, *E-mail:* assar_sh@rums.ac.ir

Introduction

Human is associated, from the breath to the digestion of food, with many types of bacteria. It's even interesting to know that for each bodily cell we have ten bacteria in our body. In fact, if we count the number, most of our body is made up of bacteria, not body cells. For thousands of years, humans have noticed the importance of bacteria in their lives. But in the last decades, we have precisely identified these ancient associates and investigated their mechanism (1). Over the past hundred years, our predecessors have provided many of their foods, such as bread, dairy and etc, by using bacteria, but no idea what the bacteria is (2).

Scientists believe that the behavioral and genetic similarities between human cells, animals, plants, and bacteria are not accidental, and these specialized cell subsets the generations of the remaining bacteria that are joined together in an integrated manner (2). To understand the efforts of researchers, those involved in the field, as well as the importance of human needs, wise people should be proud of living with bacteria and beware of their undesirable effects (3, 4).

All over the planet are involved by Bacteria, and if not, human beings could not breathe easily today. Therefore, while studying bioavailability, we must take into account the essential role of bacteria in transforming the earth into a habitable planet. Now that you read this article, millions of bacteria on/in your body are busy and active. Bacteria play an effective role in some of our body activities and we must appreciate them (5). All living beings, including humans, owe their lives to the existence of their cells. These cells form the primary units of life, and the findings of scientists suggest that the relationship between bacteria and other creatures occurred about 2 billion years ago (6). Though non-scientific characters such as actors and football players are at the center of the view, the scientific community has relatively respectable the great inventors and discoverers. This is also an impressive price, like Oskar, at a breakthrough price; The Nobel Price. Of course, nobody can win the Nobel Prize, However, it is something that all scientists think about (6, 7).

We have a large number of great microbiologists who have changed our lives. Medical scientists have made many efforts, discoveries, and inventions that make us alive and in good health (8). One of the great related scientists is the Louis Pasteur, The Father of Microbiology, who made a huge contribution to technology and medicine. He was a scientist who studied the fermentation of food elements which led to the discovery of microbes. He also made a presentation on the emergence of life and published a theory called the "Germ theory" (9). He developed a complex process for the sanitization of milk from probable germs which is known as "pasteurization". In addition, Pasteur was the first scientist who explored rabies and anthrax vaccines as well as the treatment of puerperal sepsis (10).

Another great and genius scientist who won the Nobel Prize of 1908, was Paul Ehrlich. Pasteur's Life and work can be divided into three extraordinarily high-level works. His first work was to color the tissues, then, his activity for the advancement of immunology and eventually, the treatment of infectious diseases using chemical compounds. Paul Ehrlich could be a man whose success was based on his great interest in scientific activity. He is called the father of chemotherapy (11, 12).

The Nobel Prize

The first and best-known scientific prize is the Nobel Prize (13, 14), named after Alfred Bernard Noble, which is awarded in four disciplines to the finest scholars in physics, chemistry, physiology or medicine, and economic and two non-scientific disciplines of literature and peace worldwide. It is the most prestigious award is given to a scientist

in the field of sciences (15). In the year 1895, one year before his death, Alfred Nobel, inventor of dynamite, in order to compensate the unsustainable uses of his invention, devoted almost all his fortune to the foundation a prize to promote the scientific humanitarian efforts. The award includes a gold medal, a diploma of honor and some cash per discipline, a total of nearly US$ 1.2 million, which is often awarded to scholars to fund continuous research. The nomination and winning bidding process have been long and scrupulous, and this has led the Nobel Prize award being superior to other awards (16).

Selection of candidates

Depends on the profits of the Nobel Foundation the Nobel Prize will be awarded to the winners. It seems that there is no systematize instruction for selecting the best candidate, and as a result, according to the precise decision of the related committee, the prize is dedicated to the most important and most outstanding work. The members of this committee are appointed by the Nobel Institute in Karolinska Stockholm, with 50 members. Of course, if they are chosen in a discipline of two, this award is usually divided equally between them. If more than two persons (but not more than three) are selected in a discipline, the selection committee award it to three (7). Therefore, the Nobel Prize in Physiology or Medicine, yearly awarded by the Nobel Foundation for outstanding discoveries in the biological and medical sciences beneficial to humans- only to an individual or individuals who have a key role in the most important initiatives, creativity, and innovation on the field of Physiology or Medicine. This is one of the five Nobel Prizes presented by the Nobel Assembly at the Karolinska Institute of Stockholm, Sweden (17, 18). It should be recalled that candidates for the award of the Nobel Prize in medical science or physiology based on a specific mechanism are selected by the Nobel Foundation, and no one can nominate himself as a candidate for this award outside the specified framework (19) (https://www.nobelprize.org/prizes).

Alfred Nobel was keen on medical research. This scientific field, medical sciences or physiology, was the third favorite Nobel interest in which he was awarded a prize in his will. In 1890 he met a Swedish physician, Johan Erik Johansson, and signed a short time contract, at his Laboratory in the Sevran region of France, with him. Because of the limitation in a number of Nobel awards, many of Excellent and outstanding scientists are not able to receive it, but there is no doubt, they have been changing our medical status through their creativity and discoveries (6). Over the past years, tremendous advances made in microbiology from disease-specific discoveries to fundamental insights, demand more efforts in medical sciences and there are lots of unproven facts to discover (20).

Main point

Related articles were found by searching Google, Google Scholar and PubMed databases using the keywords; Nobel Prize, Medicine, Bacteriology and the name of each Bacteriologist winner separately. The present study attempted to answer the following questions: what is the Nobel Prize? What is the brief history of the laureates? How did they deserve to achieve the prize? How to be successful to get Medical Bacteriology prize? Here, we focus on the bacteriologists who have received the Nobel Prize for Physiology and Medicine so far (Table 1).

Nobel Prize winners in the field of medical bacteriology until 2018

The Nobel Prize in Physiology or Medicine 1901 was awarded to Emil Adolf von Behring (1854-1917) for his work on serum therapy, especially its application against diphtheria, by

which he has opened a new route in the domain of medical science and thereby placed in the hands of the physician a victorious weapon against illness and deaths (21).

In 1878, at the end of primary education, he arrived and studied at the "Friedrich Wilhelm" University and succeeded in obtaining a doctoral degree in medicine. Then he worked as an assistant surgeon in the army. Since 1888, he has been teaching at the Army Medical School and was hired next year at the Institute of Controversial Medicine. Dr. Koch's students discovered microbes that were the cause of the disease, but Behring was thinking about the destruction of microbes and the result of his study was raised in an article "Infection and Antimicrobial in the theory and practice". In 1890, he concluded that if the blood of a tetanized animal transmitted to a non-tetanized animal, it would be immune to tetanus, thus making tetanus vaccine (22). The same procedure was applied by Dr. Behring. Finally, he and the Hoechst company commercialized the antidote in 1892 (23-25). The feature of this serum was not only immunity but also had a protective effect and thus, it was the start of the serum therapy (26).

The Nobel Prize in Physiology or Medicine 1905 presented to Robert Heinrich Hermann Koch (1843-1910) for his investigations and discoveries in relation to tuberculosis. He was a famous German physician and microbiologist and is known as the father of microbiology. Koch was able to detect bacterial infectious diseases particularly tuberculosis, cholera, and anthrax. By studying human specimens, the great scientist discovered the causes of infectious diseases. Robert Koch developed and improved the technologies and techniques of studying microbes, and discovered a lot of public health issues. One of the most prominent results of his research is known as Koch postulate (27). These indicators link specific microorganism to a specific disease and are now used as microbiological golden rules (28). For the first time, he used an Agar to solidify the culture media.

Robert Koch was elected to the Royal Society of England in 1897. This association donates the peer-reviewed title to individuals who have significant discoveries in various fields, including mathematics, natural sciences, engineering sciences, as well as medicine. Koch received the Nobel Prize in Medicine in 1905 for discovering TB and Robert Koch's Institute took his name in honor of him (2).

In 1928, Charles Jules Henri Nicolle (1866-1936) granted the Nobel Prize in Physiology or Medicine for his work on typhus. In 1906 he and his colleagues began their first studies in typhus disease and discovered the causative relationship between louse (Pediculus humanis corporis) as a vector and the bacterial agent of typhus disease, a disease in which the small bacteria being seen in the cells of the patients. The infectious agent of typhus is a small bacterium and intracellular parasite. Their appearance is rod or spherical. From 1903 to his death in 1936, he was a director of the Pasteur Institute in Tunisia (29-32). Nicolle made a great contribution to the twentieth century’s events (33) (Charles Nicolle – Nobel Lecture. NobelPrize.org. Nobel Media AB 2018).

The Nobel Prize in Physiology or Medicine 1945 allocated to Sir Alexander Fleming (1881–1955) for the discovery of penicillin and its curative effect in various infectious diseases. For years penicillin saved the lives of millions of people by diminishing the risk of death and infectious diseases. Fleming was a genius student at St Mary's Medical College and expanded his studies on many related bacteriologic works such as anatomy, pathology, and pharmacology until finally discovered penicillin in 1928 (34, 35).

After receiving Doctoral degree at St. Mary's Hospital, Fleming joined Edward Wright's students at Sir Allmut, with the disparity of taste he had worked with for 40 years (36). Fleming was very interested in microbiology. After graduation, he studied immunology and

Table 1. List of the Nobel Prizes on the Physiology and Medicine Between1901 and 2018.

Nobel Prize	Number of Prizes	Number of Laureates	Awarded to one Laureate	Shared by two Laureates	Shared by three Laureates
Physiology & Medicine	109	216	39	33	37
Field of Bacteriology	6	9	4	1	1
Presented to Bacteriolgists	1901-2005	9	1901, 1905, 1928 and 1952	2005	1945

immunity. Fleming began his research on *Staphylococcus aureus* and tested different culture media for the growth of this microbe (23). Fleming isolated a mold which was called Penicillium. By now, penicillin (one of the products of Penicillium) is produced by various species of Penicillium and Aspergillus. During the first international war, Fleming joined the medical unit of the British Army as a rank-and-file lieutenant and began to work at the Wounded War Research Laboratory. In a simple but clever way, it showed the inability of chemical antiseptics to disinfect deep wounds. In 1945, Fleming received the Nobel Prize in medical sciences, 33% in conjunction with Ernest Chain and Howard Florey for the discovery of penicillin (37, 38).

The Nobel Prize in Physiology or Medicine 1945 awarded to Ernest Boris Chain (1906 - 1979), for the discovery of penicillin and its curative effect in various infectious diseases. He was a German-born British biochemist. He was isolated and purified penicillin which was the first clinical antibiotic. Penicillin, "an antibiotic revolution", was used by the general public in 1941 (13, 39-41). It seems that the discovery and application of penicillin are as great as the discovery of germs by Pasteur. It should be mentioned that Fleming obtained the prize for the discovery of the bactericidal effect of Penicillin, but Chain and Florey for the isolation and preparation of it as a drug (41).

It was said before that, Sir Howard Walter Florey) 1898-1968), awarded for the discovery of penicillin and its curative effect in various infectious diseases. The outstanding Australian scientist Florey was born in 1898 in Adelaide, Australia. Howard was among the youngest of his seven siblings. He first went to St. Peters College and during the years 1917 to 1921 attended the University of Adelaide in pharmacology. Then he went to England to continue his education and was able to win a scholarship from the University of Cambridge. In 1926 he received his doctorate in the University of Cambridge. After that, he went to the University of Sheffield, where he taught pathology and later moved to Oxford University in 1935, and along with teaching pathology with Boris Ernst Chain led a research team for working on the mass production of penicillin (13, 42).

Selman Abraham Waksman (1888-1973) An American biologist, Ukrainian descent, won the Nobel Prize in Physiology or Medicine of 1952 for streptomycin discovery, the first effective antibiotic against tuberculosis. The term

"antibiotic" was used to refer to an antibacterial chemical substance derived from microorganisms. Streptomycin which is derived from Streptomyces is used to treating brucellosis and plague. Waksman isolated many new antibiotics including streptomycin and neomycin. These drugs were widely used to treat various diseases in plants, animals, and humans. In some period, excessive use of antibiotics and the production of new antibacterials have led to the development of new species of bacteria (13, 43, 44).

The Nobel Prize winner in Physiology or Medicine 2005 awarded to Barry James Marshall and J. Robin Warren for the discovery of Helicobacter pylori, a bacterium, and its role in gastritis and peptic ulcer. Marshall was born in 1951 in Kalgoorlie, Western Australia. In 1984, he called this agent Campylobacter pylorus, but the organism differed from the Campylobacter. For this reason in 1989, Goodwin and his colleagues created a new genus called Helicobacter (45-47).

Up to now, more than 12 species of Helicobacter have been found to be of human origin, not all of which are paramount importance. H.pylori is a spiral bacterium that researchers believe gastrointestinal ulcers are caused by its function, associated with the toxin. Contamination of this bacterium in Canada and the United States is more than elsewhere in the world. Statistical studies have shown that about 25% of people under 40 years of age and half of those over 50 years of age have been infected with this bacterium (48-50).

The Nobel Prize winner in Physiology or Medicine 2005, James Robin Warren was born in 1937 in North Adelaide, South Australia. He and Barry J. Marshall allocated the prize as mentioned before. From its introduction to the world, many advances have been made in discovering the pathogenicity of Helicobacter. Every day, there is a new window opening on the role of this microbe in the development of various types of gastrointestinal lesions and even gastrointestinal diseases. Conflict with this bacterium has a high prevalence among patients and healthy people in the community (46, 51, 52).

Conclusion

By the present, nine microbiologists have been awarded the Nobel Prize in the field of medical Bacteriology. Therefore, more knowledge about the relationships between bacteria and their host (humans), make it possible to control and treat infectious diseases or returning ones. Nobel prizes are very valuable, but more valuable are those who have won the Nobel Prize. Nobel winners are thinkers who have dedicated their lives to revealing the secrets of human life. They have contributed to the promotion of collective intelligence, and some of them have transformed human life with their studies. Nowadays, joint works with different disciplines have increased global collaborative efforts in scientific studies.

When most significant work is the result of collaborative research, limit the price to a maximum of three people at a time is undoubtedly the main source of controversy over the Nobel Prize. A simple solution to this problem would remove the restriction on the number of people who could receive the award. It will be a wise solution to recognize all those who contributed to scientific work. Such a change in the Nobel Prize awarding may attribute to the organization, institution, etc. To reduce the negative impact of competition among scientists and encouraging collaboration, it is better to award the prize to all of the teamwork in a planned discipline. Also, we propose to encouraging learning, condemning laziness, cherishing researcher, rejecting imitation and emphasizing science.

Almost all of the scientists awarded the Nobel prize in the field of bacteriology belong to the first and mid decades of the 20th century. The only case in the 21st century was acquired by Marshal and Warren for discovering of

Helicobacter pylori in the year 2005. It seems it is needed to have some outstanding works to acquire Nobel Prize in the basic and medical bacteriology.

Acknowledgment

We appreciate the Rafsanjan Medical School, who provide studying literature and using all possibilities for the presentation of this narrative review.

Conflict of interest

No declared.

References

1. Noble D. Evolution viewed from physics, physiology and medicine. *Interface focus* 2017; **7**(5):20160159.
2. Kaufmann SH, Schaible UE. 100th anniversary of Robert Koch's Nobel Prize for the discovery of the tubercle bacillus. *Trends Microbiol* 2005; **13**(10):469-75.
3. Wells G, Claxton G. Learning for life in the 21st century: Sociocultural perspectives on the future of education. 2nd, Wiley-Blackwell, United States 2008.
4. Hansson GK. Dr Jérémy Fauconnier talks with Prof Göran K. Hansson. *Cardiovasc Res* 2017; **113**(14):e57-e8.
5. Hodson D, Wong SL. From the Horse's Mouth: Why scientists' views are crucial to nature of science understanding. *Int J Sci Educ* 2014; **36**(16):2639-65.
6. Schneider JW, Costas R. Identifying potential "breakthrough" publications using refined citation analyses: Three related explorative approaches. *J Assoc Inf Sci Technol* 2017; **68**(3):709-23.
7. Myers KR. The Direction of Biomedical Science 2016. Retrieved May 21, 2019 from http://www.nber.org/aging/valmed/WhitePaper-Myers11.28.2016.
8. Brown ED, Wright GD. Antibacterial drug discovery in the resistance era. *Nature* 2016; **529**(7586):336.
9. Geison GL. The private science of Louis Pasteur: Princeton University Press 2016. Retrieved May 21, 2019 from; https://press.princeton.edu/titles/5670.html.
10. Press SJ, Tanur JM. The subjectivity of scientists and the Bayesian approach. New York: Wiley 2001.
11. Strebhardt K, Ullrich A. Paul Ehrlich's magic bullet concept: 100 years of progress. *Nat Rev Cancer* 2008; **8**(6):473.
12. Kaufmann SH, Winau F. From bacteriology to immunology: the dualism of specificity. *Nature immunol* 2005; **6**(11):1063.
13. Cabantchik Z, Drakesmith H. From one Nobel Prize (P. Ehrlich) to another (Tu Youyou): 100 years of chemotherapy of infectious diseases. *Clin Microbiol and Infect* 2016; **22**(3):213-4.
14. Lichtman MA. Alfred Nobel and His Prizes: From Dynamite to DNA. *Rambam Maimonides medical journal* 2017; **8**(3):e0035.
15. Foster JG, Rzhetsky A, Evans JA. Tradition and innovation in scientists' research strategies. *Am Sociol Rev* 2015; **80**(5):875-908.
16. Tiwari PM. Nobel Prize Winners of the World. New delhi. Diamond Pocket Books Pvt Ltd; 2014 ;26.
17. Johnsen I. Conceptualizing the state within: Norway, the Nobel Committee and the Nobel Peace Prize (Master's thesis, Norwegian University of Life Sciences) 2012.
18. Tatsioni A, Vavva E, Ioannidis JP. Sources of funding for Nobel Prize-winning work: public or private? *The FASEB Journal* 2010; **24**(5):1335-9.
19. Merali Z. The new Nobels. *Nature* 2013; **498**(7453):152.

20. Casadevall A, Fang FC. (A)Historical Science. *Infect Immun* 2015; **83**(12):4460-4.
21. Rosen W. Miracle cure: the creation of antibiotics and the birth of modern medicine. London: Penguin 2017.
22. von Behring E. Medicine's first Nobel laureate. *Singapore Med J* 2011; **52**(1):1.
23. Bertheim A. Pioneers in Antimicrobial Chemotherapy. *J Assoc Physicians India* 2015; **63**:90.
24. Cavaillon J-M. Historical links between toxinology and immunology. *Pathog Dis* 2018; **76**(3):fty019.
25. Denscombe M. The good research guide: for small-scale social research projects. McGraw-Hill Education (UK); 2014.
26. Graham BS, Ambrosino DM. History of passive antibody administration for prevention and treatment of infectious diseases. *Curr Opin Hiv Aids* 2015; **10**(3):129.
27. Blevins SM, Bronze MS. Robert Koch and the 'golden age'of bacteriology. *Int J Infect Dis* 2010: **14**(9):744-51.
28. Lagier JC, Dubourg G, Amrane S, et al. Koch postulate: why should we grow bacteria?. *Arch Med Res* 2017; **48**(8):774-9.
29. Schultz MG, Morens DM. Charles-Jules-Henri Nicolle. *Emerg Infect Dis* 2009; **15**(9):1519.
30. Rumi JA. The Masnavi. Book Four. Oxford University Press 2017.
31. Bloom DE, Black S, Rappuoli R. Emerging infectious diseases: a proactive approach. *Proc. Natl Aca Sci* 2017; **114**(16):4055-9.
32. Ergonul O, Yalcin CE, Erkent MA, et al. Who can get the next Nobel Prize in infectious diseases? *Int J Infect Dis* 2016; **45**:88-91.
33. Dworkin J, Tan SY. Charles Nicolle (1866-1936): bacteriologist and conqueror of typhus. *Singapore med j* 2012; **53**(11):764-5.
34. Hollar S, editor. Pioneers in medicine: From the classical world to today. Britannica Educational Publishing; *Phys. Rev* 2012; **47**:777-80.
35. Shama G. La Moisissure et al. Bactérie: deconstructing the fable of the discovery of penicillin by Ernest Duchesne. *Endeavour* 2016; **40**(3):188-200.
36. London HU. Capstone Project: historical analysis of the development of penicillin (Doctoral dissertation, Worcester Polytechnic Institute) 2018:2-29
37. Breedlove B, Arguin PM. The new incurable wound. *Emerg infect dis* 2016; **22**(9):1696.
38. Ramalingam AJ. History of Antibiotics and Evolution of Resistance. *RJPT* 2015; **8**(12):1719.
39. Sebastian A. A dictionary of the history of medicine. *Routledge* 2018; **6**.
40. Cozzoli D. Penicillin and the European response to post-war American hegemony: the case of Leo-penicillin. Hist Technol 2014; **30**(1-2):83-103.
41. Ligon BL. Penicillin: its discovery and early development. *In Seminars in Pediatric Infectious Diseases* 2004; **15**(1):52-7
42. Kyle RA, Steensma DP, Shampo MA. Howard Walter Florey—production of Penicillin 2015; **90**(6):e63-e64.
43. Woodruff HB. Selman A. Waksman, winner of the 1952 Nobel Prize for physiology or medicine. *Appl Environ Microbiol* 2014; **80**(1):2-8.
44. Waksman SA. Immunologists and Virologists 2014:111-8.
45. Marshall B. A Brief History of the Discovery of *Helicobacter pylori*. *Helicobacter pylori* 2016; 3-15.
46. Malfertheiner P, Link A, Selgrad M. *Helicobacter pylori*: perspectives and time trends. *Nat. Rev. Gastroenterol. Hepatol* 2014; **11**(10):628.
47. Zanoni RG, Piva S, Florio D, et al. *Helicobacter apri* sp. nov., isolated from wild boars. *Int J Syst Evol Microbiol* 2016; **66**(8):2876-82.

48. Kyle RA, Steensma DP, Shampo MA. Barry James Marshall—Discovery of *Helicobacter pylori* as a cause of peptic ulcer. *In Mayo Clinic Proceedings* 2016; **91**(5):67-8.
49. Øverby A, Murayama SY, Matsui H, Nakamura M. In the aftermath of *Helicobacter pylori*: other Helicobacters rising up to become the next gastric epidemic? *Digestion*. 2016; **93**(4):260-5.
50. Ezzati M, Pearson-Stuttard J, Bennett JE, et al. Acting on non-communicable diseases in low-and middle-income tropical countries. *Nature* 2018; **559**(7715):507.
51. Steensma DP, Kyle RA, Shampo MA. J. Robin Warren: *Helicobacter pylori* and peptic ulcer. *In Mayo Clinic Proceedings* 2016; **91**(9):129-30.
52. Pajares JM, Gisbert JP. *Helicobacter pylori*: its discovery and relevance for medicine. *Revista Espanola de Enfermedades Digestivas* 2006; **98**(10):770-85.