

Allah's Wondrous Creatures, the Holy Qur'an and Technological Inventions: Ultrasound Imaging

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ABSTRACT

Allah (s.w.t) has created innumerable distinct creatures and mentioned to us about their special qualities through His revelation. The Qur'an is the ultimate source of guidance for its followers for all aspects of life including science. If one is to study nature scientifically there are countless observable facts that are parallel to the teachings of Islam. One of these facts is echolocation found in bats and dolphins. These animals generate ultrasonic signals and detect the echoes reflected back to them to map out their environment and catch prey. Modern health sciences have already adopted this phenomenon in the form of ultrasound imaging for diagnosis of certain diseases. However, there is room for improvement in the overall performance of this technique. This article highlights the technological developments directly inspired by nature i.e., crawfish/crayfish and relates echolocation characteristics of bats and dolphins with basic principles of ultrasound imaging. In-depth studies on the echolocation properties of these creatures can lead to further improvement in the current ultrasound imaging technique. Such as; the construction of a transducer which simultaneously generates multi-frequency ultrasound signals and development of new interpreting software. Moreover, reading verses of the Holy Qur'an heartily and enthusiastically will lead to the development of innovative ideas that can be translated into reality and applied for the betterment of humankind.

KEYWORDS Allah's wondrous creatures, the Qur'an, Bat, Dolphin, Ultrasound Imaging, Islamic Perspective, Science

INTRODUCTION

Almighty Allah (s.w.t) sent down the Qur'an as an ultimate book of guidance to humanity more than fourteen hundred years ago. First word revealed to the Prophet Muhammad (pbuh) was *Iqra*, meaning, "read" (Al-Qur'an 96:1)¹. The meaning of the Qura'nic word *Iqra* is not just to read, but it is to study, understand, observe, investigate, analyze, learn, discover and innovate. The first five verses of Surah Al-'Alaq, which make up the first revelation, pay emphasis on the acquirement of knowledge. In these verses Allah (s.w.t) instructs and encourages humankind to read and gain knowledge about everything created by Him in this Universe. Translation of these verses is given as under:

"Recite in the name of your Lord who created - Created man from a clinging substance. Recite and your Lord is the most Generous - Who taught by the pen - Taught man that which he knew not." (Al-Qur'an 96:1-5)¹

In this article, basic principles of medical ultrasound imaging technique have been related with the characteristics of creatures of Almighty Allah (s.w.t), i.e., bat and dolphin in terms of generating

and detecting the range of ultrasound signals for mapping the environment surrounding them. Also suggestions are given based on the characteristics of these creatures to develop a novel transducer for ultrasound imaging equipment. Hence, new computer programs and design of a new and improved ultrasound imaging system can be developed. Thus, ultrasound-imaging technique may be applied more frequently for diagnosis of a variety of diseases and treatment of some abnormalities in future. It should be noted that ultrasound imaging technique is safer (in terms of radiation dose), cost effective, portable and takes shorter image acquisition time as compared to x-ray and radionuclide imaging techniques.

The Qur'an and Its Marvels

The Qur'an, first and foremost is not specifically a book of science. It is divinely revealed from Allah (s.w.t), Who is the True and the Only Creator of this Universe, to cover every aspect of human life. However, many verses of the Qur'an contain scientific facts, which have proven to be highly accurate by modern science recently. Similar views have been shared in recent publications.^{2,3} Some such examples include facts about embryology, biology, water cycle and conquest of space.

The Qur'an continually invites the believers to seek knowledge, encourages the use of intellect (brain power), calls people to think, explore, inspect, evaluate and analyze. Allah (s.w.t) instructs the

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entire humanity in many verses of the Qur'an to investigate the heavens, the earth, living things and even their own existence. At the same time it makes a number of annotations on phenomena that motivate and activate intellectual effort, e.g., creation of man, sky - how it was raised up? moon a light and sun a lamp, sequence of day and night, settled place for a sun and expansion of the universe. The Qur'an repeatedly expresses: Why do they not reflect? Why they do not ponder?

"There are seven hundred and fifty verses of the Quran (almost one-eighth of the Book) exhort believers to study Nature, to reflect, to make the best use of reason in their search for the ultimate and to make the acquiring of knowledge and scientific comprehension part of the community's life." (Abdus Salam, 1984)⁴.

The translations of some Qura'nic verses among many are presented here, in which, there are indications and instructions for us to think over, explore and understand the universe and to learn/know more about the Creator Almighty Allah (s.w.t). The following verses specifically compel us to ponder over nature and its buildup.

"Have they not looked at the heaven above them - how we structured it and adorned it and [how] it has no rifts? And the earth - We spread it out and cast therein firmly set mountains and made grow therein [something] of every beautiful kind, Giving insight and a reminder for every servant who turns [to Allah]." (Al-Qur'an 50:6-8)¹

Other verses that remind and invite the humankind to observe and think about the creation of living and non-living things from which beneficial knowledge can be driven include.

"Then do they not look at the camels - how they are created? And at the sky - how it is raised? And at the mountains - how they are erected? And at the earth - how it is spread out? So remind, [O Muhammad]; you are only a reminder." (Al-Qur'an 88:17-21)¹

Again humankind is suggested to ponder and explore. This is evident in the following verse.

"And He has subjected to you whatever is in the heavens and whatever is on the earth - all from Him. Indeed in that are signs for a people who give thought." (Al-Qur'an 45:13)¹

The following verses cite the importance of contemplating about the Creator of this universe so that one can fully comprehend and benefit from the numerous blessings bestowed upon humankind.

"Indeed, in the creation of the heavens and earth, and the alternation of the night and the day, and the [great] ships which sail through the sea with that which benefits people, and

what Allah has sent down from the heavens of rain, giving life thereby to the earth after its lifelessness and dispersing therein every [kind of] moving creature, and [His] directing of the winds and the clouds controlled between the heaven and the earth are signs for a people who use reason." (Al-Qur'an 2:164)

This verse too notifies the importance of reflecting and learning.

"And it is He who spread the earth and placed therein firmly set mountains and rivers; and from all of the fruits He made therein two mates; He causes the night to cover the day. Indeed in that are signs for a people who give thought." (Al-Qur'an 13:3)¹

The following verses point out that there are various signs for the wise to gain beneficial knowledge from.

"[It is He] who has made for you the earth as a bed [spread out] and inserted therein for you roadways and sent down from the sky, rain and produced thereby categories of various plants. Eat [there from] and pasture your livestock. Indeed, in that are signs for those of intelligence." (Al-Qur'an 20:53-54)¹

All the verses cited including the following give prime importance to deep thinking from religious, social, economic and scientific perspective.

"And indeed, for you in grazing livestock is a lesson. We give you drink from what is in their bellies - between excretion and blood - pure milk, palatable to drinkers." (Al-Qur'an 16:66)¹

"And to Allah belongs the dominion of the heavens and the earth, and Allah is over all things competent. Indeed, in the creation of the heavens and the earth and the alternation of the night and the day are signs for those of understanding." (Al-Quran 3:189-190)¹

The preaching of Prophet Muhammad (pbuh), are the ground rules of inspiration and encouragement for learning and seeking of knowledge. In this respect, following are the frequently quoted statements of Prophet Muhammad (pbuh).

*"Seeking knowledge is compulsory on every Muslim" (Tirmidhi)
"Whoever follows a path seeking knowledge, Allah will make his path to paradise easy" (Sahih Muslim)*

Maurice Bucaille⁵ stated in the booklet "The Qur'an and Modern Science" that there are enormous scientific assets in the verses of the Qur'an. But because of insufficient scientific knowledge humankind was unable to study the verses of the Qur'an from this perspective for many centuries. Despite the fact that, scientific knowledge,

techniques and many specialized disciplines have been developed in recent times, however they lack the Qur’anic perspective. Yet it is not easy for an average scientist to understand everything by merely reading the verses of the Qur’an. Thus, a scientist does not only require high-level research skills, knowhow of techniques and more than adequate knowledge of a number of scientific disciplines. He/she should also master the methods of understanding and combining the rich knowledge provided by the Holy Qur’an. Moreover, studying the Qur’an deeply and understanding the characteristics of few of all that Almighty Allah (s.w.t) has brought to existence, provides a strong reason to be grateful to the Creator and gives the evidence of the extent of His Sovereignty.

Allah’s Creatures: Technological Inventions

Almighty Allah (s.w.t) has created countless living and non-living things on and under the earth, in the sky and under the sea/water. They are wondrous, amazing, mysterious and perfect in their places. Nothing is created by Allah (s.w.t) without any use or reason. In this modern scientific and technological age, nature inspired scientists and scholars have explored and studied some biological/non biological systems/objects in order to understand their development, functions and characteristics. In this section scientists and technologists who are inspired from the shape and working characteristics of some creatures present few examples among the many relating to the technological inventions, which are made. For example, twin arm demolisher as shown in Figure 1a. In 2006 New Energy and Industrial Technology Development (NEDO), Japan developed a new twin arm hydraulic excavator named as ASTACO.⁶ In Spanish ASTACO means crawfish/crayfish, shown in Figure 1b. The design of arms of the demolisher resembles the arms of crawfish. The advantages of new double arm demolisher are enormous as compared to single arm, e.g., very efficient in complex situations, emergencies, disasters and humanitarian rescue efforts. In addition, with both the arms it can easily break the debris during most dangerous operations.



Figure 1. Shows (a) the twin arm demolisher (b) crawfish/crayfish (<http://www.discoverychannelasia.com/shows/super-japan/>)

Another example is the silk of spider, which is one among the most incredible natural materials in terms of the properties, e.g., strength and elasticity. Scientists were inspired from the hanging spider, by looking at the size (weight of spider) and thickness of the silk (thread). Studies show that, spider’s silk is a magical protein fiber. The strength of the silk is five times the steel and stretches up to five times of the length without any damage/break.⁷ These properties forced the scientists’ to investigate further about the molecular structure of spider silk and fabricate the new thread having the similar properties as the spider silk posses. Literature shows that, the artificial / synthetic fiber can be used in different areas, such as; medicine and defense. In medicine, silk can be used for skin repair of burn victims, artificial tendon, elastic ligaments and surgical sutures.^{8,9}

Ultrasound Signal Generating Creatures

It is impossible for human beings to study each and every thing, which exists in this universe. Nevertheless, enormous efforts have been made by researchers relating to some of the creatures, e.g., humans, birds, animals, insects, clouds, etc.

Humans cannot hear/detect sounds that have frequencies lower than 20 Hz (infrasound) or above 20 kHz (ultrasound); they only can hear 20 Hz - 20 kHz ranges of frequencies. Some species appear quite silent for us, but in fact they are very noisy and the reason is that we cannot detect their sound since they emit infrasound and ultrasound signals. Hearing frequency range for selected animals is shown in Table 1.

Table 1: Infra and ultrasound hearing frequency range (approximate) of selected animals (Modified from https://soundphysics.ius.edu/?page_id=903)

Animals	Frequency (Hz)	
	Low	High
Cat	45	64 k
Horse	55	33.5 k
Elephant	16	12 k
Bat	2 k	110 k
Bottlenose Dolphin	90	105 k

Bats

Bats are one of the creatures among the countless creations of Almighty Allah (s.w.t). These are considered among the extraordinary mammal orders with gifted ability to fly in complete darkness. Bats emit ultrasound waves to find the path (navigate) as well as map-surrounding environment to track down the prey in the dark. Bats, thus, possess exceptional echolocation capabilities.

Bats fall under the mammalian order of 'chiroptera' hand-wing (mega and micro). In 1958 Griffin¹⁰ studied and discovered that bats generate ultrasonic signals and detect the sound bounced back caused by the obstruction of objects in the path of ultrasonic signals to navigate and catch the prey as shown in Figure 2. Griffin¹⁰ termed this phenomenon as "echolocation".

Griffin¹¹ mentioned that, early experimental studies were conducted by Lazzaro Spallanzani in 1793 on bats' navigation and location characteristics. He further added that, in 1932, more than a century later, a Dutchman Sven Dijkgraaf noticed that bats avoided obstacles using sound. Altringham¹² stated that bats produce echolocation signals in pulses. According to Grinnell¹³, ultrasonic signals emitted by bats used for echolocation, which range from 25 kHz to 100 kHz. However, some species emit and examine main components as high as 150 kHz. The properties of echolocation sound pulses vary from species to species and are associated with the chasing tactics and means of information processing.¹³ A large number of bat families generate echolocation signals of short and downward frequency-modulated (FM) which sweep through an octave and are known as FM bats.



Figure 2. Bat uses ultrasound waves to target the food by hearing echoes return from the object (image of bat taken from https://cmns.umd.edu/sites/default/files/images/news/flying_bat_0.jpg)

There is another family of bats called as Long CF/FM bats. The pattern of echolocation sounds is of constant-frequency (CF). Out of three different families, a smaller number of species use Long CF/MF signals. A long (10 - 100 ms) constant-frequency part precedes an FM sweep.¹³ The constituent of constant-frequency ranges

approximately 60 - 62 kHz and 83 kHz. These (Long CF/MF) bats are very dedicated in terms of analyzing ultrasound signals in detail in the range of propagated CF. Furthermore; the point to be noted is that these bats usually hunt their prey in messy surroundings where it is difficult to detect for those who use only FM signals.

Several bat species make use of an intermediate pulse design, comprised on short CF pulses up to 8 - 10 ms and terminate in FM sweep. These fall under the category of Short CF/FM bats. They are less specialized as compared to Long CF/FM in terms of frequency band analysis. However, to some extent they may use Doppler shift information for echo signal analysis.¹³

Bats have the ability to modify the pulse structure according to their surroundings. Some generate FM signals only when they are close to the vegetation. In a clean environment they extend the pulse and cut down the amount of sweep in order to be able to detect weak echoes from distant targets.

Dolphins

Allah's incredible and remarkable creatures have an amazing capability and highly sophisticated sensory system of generating ultrasound waves in order to communicate with each other, determine the distance, shape, size, texture of objects and hunt their prey as shown in Figure 3. To achieve their task, dolphins detect the sound signals by emitting a range of buzzes, whistles and clicks that are bounced back by the objects in front of them. In addition to that, dolphins can track down the objects through mud and sand at three feet depth.¹⁴

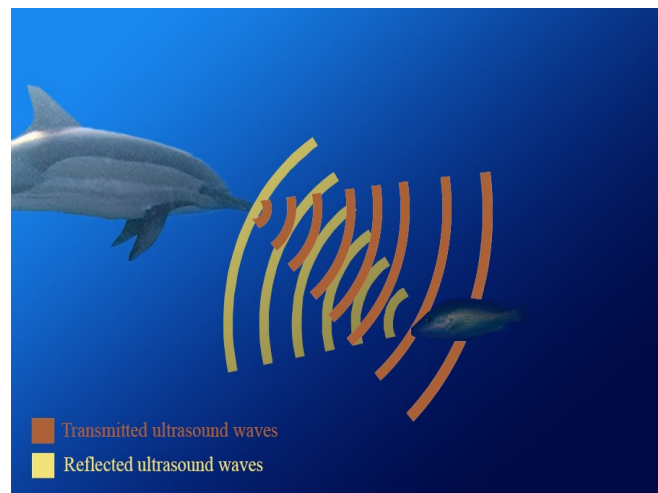


Figure 3. Show the use of biosonar characteristics of dolphin to map out the surrounding in order to find the prey (image of dolphin taken from <http://www.davoda.com/en/news/dolphins-solve-equations-while-hunting/>).

Dolphins are marine mammals' and the members of the order *Cetacea*, further, they are known as *odontocetes* under the suborder of *Cetacea*.¹⁴ Recently, it has been found by a group of researchers that dolphins can produce two sound

beam projections at the same time with distinct frequencies and dissimilar directions.¹⁵ Thus, the dolphins have the advantage to trace and locate the object more precisely. On the other hand, dolphins' echolocation is very much sophisticated in many others ways; therefore, we need to learn a lot from dolphins.¹⁵

Dolphins click in series “click trains”, which are less diverse in their composition and generally greatly shorter than bat calls, perhaps to make sure for satisfactory temporal resolution. Basically, the signals are of two types, short (high-intensity broadband in bottlenose dolphins) and long (lower-intensity more narrowband). Moreover, a latest study¹⁶ shows that freshwater dolphins emit echolocation signals at very low sound intensities relative to marine dolphins. This reflects that freshwater dolphins hunt for their prey at shorter distances.

Medical Ultrasound Imaging

Ultrasound imaging has been used as a medical imaging technique for more than five decades. This was first applied as medical diagnostic tool by an Austrian neurologist (Karl Theo Dussik) in brain imaging.¹⁷ Now it has been widely used for a number of clinical examinations, e.g., obstetrical, echocardiography, abdominal, renal, breast and thyroid. Thyroid imaging is shown in Figure 4. Images are obtained in real time; therefore, they provide instantaneous information, which is also used for many interventional procedures.¹⁸

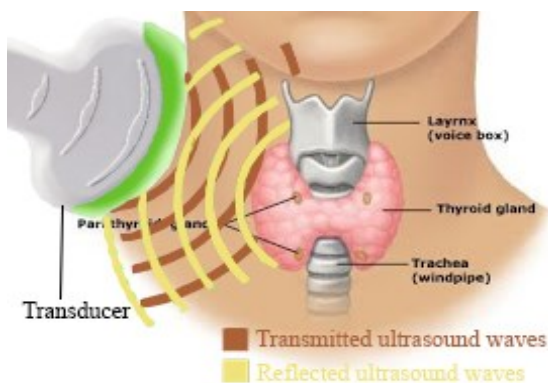


Figure 4. Transducer produces ultrasound waves to scan thyroid for diagnosis of disease (modified from <http://synergyscn.com/blog/wp-content/uploads/2013/11/Thyroid-Cancer-image.jpg> and GE Ultrasound 5125386 4C RS 4C-RS Convex Probe).

Ultrasound waves are produced in pulses which are longitudinal waves consisting of two to three sound cycles of the same frequency. These are generated by transducers, which contain piezoelectric crystals interconnected electronically that vibrate when electric current is applied - quartz crystal changes the shape with polarity. This effect causes expansion and contraction which leads to the generation of compression and rarefaction of sound waves and vice versa. Thus, the transducer

functions as a transmitter and receiver. Moreover, the piezoelectric is called as “pressure electric” effect as described by Curie brothers in 1880.¹⁹

Medical ultrasound equipment uses the ultrasound frequency ranging from 1 to 20 MHz. High frequency ultrasound signals produce high axial resolution images. The problem with high frequency signals is that they are attenuated more, relative to low frequency signals for a given distance. Therefore, for imaging superficial structures high frequency (10 - 15 MHz) ultrasound signals are applied. In contrast, low frequency (2 - 5 MHz) generating transducers are used for detecting deep structures in the body, because, these are attenuated less as compared to high frequency signals. However, the image resolution is poor. This suggests selection of proper frequency range for obtaining acceptable image resolution in diagnostic and interventional procedures is required.

Though, ultrasound imaging has significant applications in medicine, but still it has limitations with regards to image resolution and generation of artifacts, such as, reverberation artifact, side lobe artifacts, acoustic shadowing and incorrect gain. These problems have hampered the confidence in the accuracy of clinical examinations. Hence, still a lot is required to overcome these problems, which means efficiency of ultrasound imaging instrument may be improved as well as the utility of the technique in medicine may be enhanced further.

In a recent research work, Intrator and Simmons²⁰ have stated that, the creatures, e.g., bats and dolphins’ “biosonar” capabilities are superior to the ultrasound systems that have been developed so far by scientists and engineers. In a new and ongoing study, both are exploring and analyzing that how these animals detect and process the returning echoes within fractions of milliseconds and that too at a higher spatial resolution as compared to human-made ultrasound systems. Further, they have stated that, bats and dolphins have the ability to process a number of parts of information concurrently. With the utilization of a modest energy, neurons in the brain of these animals are gifted with an ability to analyze their environment at a high level differentiated three dimensionally. Humans are unable to generate such an accurate image/picture even with the help of super computers consuming thousands of times more energy.²⁰

New Ideas, Knowledge and Inventions

Allah (s.w.t) is the all knower and humans have a minutest knowledge as it can be learned from the verse of Al-Qur’an (31:27)¹:

“And if whatever trees upon the earth were pens and the sea [was ink], replenished thereafter by seven [more] seas, the words of Allah would not be exhausted. Indeed, Allah is exalted in Might and Wise.”

It is important to mention that, the mechanism of ultrasound imaging for detection of structures in human body is similar to that, bats and dolphins navigate and hunt down their prey in the dark. These creatures exist since millions of years, whereas, enormous efforts and scientific techniques have only discovered this phenomenon recently. New technical knowledge can be generated by exploring and analyzing the characteristics of aforementioned creatures, using existing scientific knowledge and techniques relevant to ultrasound imaging and drawing guidance from the verse of Al-Qur'an (40:81)¹ and other verses as mentioned above.

"And He shows you always His Signs; then which of the Signs of Allah will you deny?" (Al-Qur'an 40:81)¹

Studying the anatomy (shape) of bats' ear and dolphins' head as well as considering the other characteristics of dolphins', i.e., sending multi-frequency ultrasonic signals simultaneously for echolocations (biosonar mapping/imaging), can lead to the development of a new transducer for the ultrasound imaging system. As well as improvement in the hardware and software of existing ultrasound scanning equipment can be achieved.

CONCLUSION

A lot can be learned from the living and non-living creations which are around us created by Almighty Allah (s.w.t). By studying the Qur'an heartily and enthusiastically not only can the belief in Oneness of Almighty Allah (s.w.t) and His divine power be strengthened but new scientific and technical knowledge can be discovered as well as new inventions can be made. Further, by exploring and analyzing the characteristics of bats and dolphins new ideas and knowledge relevant to the design of ultrasound imaging transducer, data acquisition and image generation software may be developed / generated. Ultimately, may be translated into novel inventions and techniques, which in turn can be practiced for the betterment of humankind.

REFERENCES

1. Al-Qur'an
2. Munirah S, Zainul Ibrahim Z, Rozlin AR, et al. Exploring the Islamic Perspective on Tissue Engineering Principles and Practice. GJAT 2014; 4: 29-40.
3. Muhammad, MHM. The Qur'an and the Scientific Spirit: An exploration of Key Issues. Revelation and Science 2015; 5: 34-46.
4. Abdus Salam. Islam and Science - Concordance or Conflict? UNESCO House Paris. 1984. Available at: www.alislam.org/library/.../Islam-and-Science-Concordance-or-Conflict
5. Maurice Bucaille. The Qur'an and Modern Science. ed, Philips AAB, 1995. Available at: <http://www.sultan.org/articles/QScience.html>
6. Hitachi Construction Machinery. Toward a prosperous future: The future of construction

machinery seen through the development of twin arm machinery; 2010 CSR Report, p. 13 - 14. Available at:

<https://www.hitachim.com/global/pdf/generator/company/csr/report10/08.pdf>

7. Lingling Xu, Marie-Laurence T, Kathleen EO, et al. Roles of Spider Wrapping Silk Protein Domains in Fibre Property. Biophysical Journal 2015; 108: 484a. [http://www.cell.com/biophysj/abstract/S0006-3495\(14\)03858-2](http://www.cell.com/biophysj/abstract/S0006-3495(14)03858-2)
8. Sarah F. Spider-Silk Superpowers. 2012. Available at: <http://www.popularmechanics.com/science/health/g741/6-spider-silk-superpowers/?slide=1-7>
9. Saravanan D. Spider Silk - Structure, Properties and Spinning. Journal of Textile and Apparel, Technology and Management 2006; 5: 1-20. https://wet.kuleuven.be/wetenschapinbreedbeeld/lesmateriaal_biologie/saravanan.pdf
10. Griffin DR. Listening in the Dark. 2nd ed. New Haven, Connecticut: Yale University Press; 1958.
11. Griffin DR. Echoes of Bats and Men. New York: Anchor Books Doubleday; 1959.
12. Altringham JD. Bats: Biology and Behaviour. Oxford: Oxford University Press; 1996.
13. Grinnell AD. Hearing in bats: An overview. In Popper AN and Fay RR, eds, 'Hearing by Bats'. Springer-Verlag; 1995.
14. Wursig B. Cetaceans. Science, New Series 1989; 244: 1550-1557.
15. Starkhammar J, More PW, Talmadge L, et al. Frequency-dependent variation in the two-dimensional beam pattern of an echolocating dolphin. Biology Letters 2011; DOI:10.1098/rsbl.2011.0396
16. Frants HJ, Alice R, Rubaiyat MM, et al. Clicking in Shallow Rivers: Short-Range Echolocation of Irrawaddy and Ganges River Dolphins in a Shallow, Acoustically Complex Habitat. PLoS ONE 2013; 8: e59284; DOI: 10.1371/journal.pone.0059284
17. Edler I, and Lindstrom K. The history of echocardiography. Ultrasound Med. Biol 2004; 30: 1565-1644.
18. Chan V, Perlas A. Basics of Ultrasound Imaging. In Narouze SN, eds. Atlas of Ultrasound-Guided Procedures in Interventional Pain Management 2011; DOI 10.1007/978-1-4419-1681-5_2, © Springer Science + Business Media.
19. Otto CM. Principles of echocardiographic image acquisition and Doppler analysis. In: Textbook of Clinical Echocardiography. 2nd ed. Philadelphia: WB Saunders 2000; 1 - 29.
20. Intrator N, Simmons J. Bats, dolphins, and mole rats inspire advances in ultrasound technology. American Friends of Tel Aviv University. ScienceDaily, 15 November 2011. <www.sciencedaily.com/releases/2011/11/11114112240.htm>.