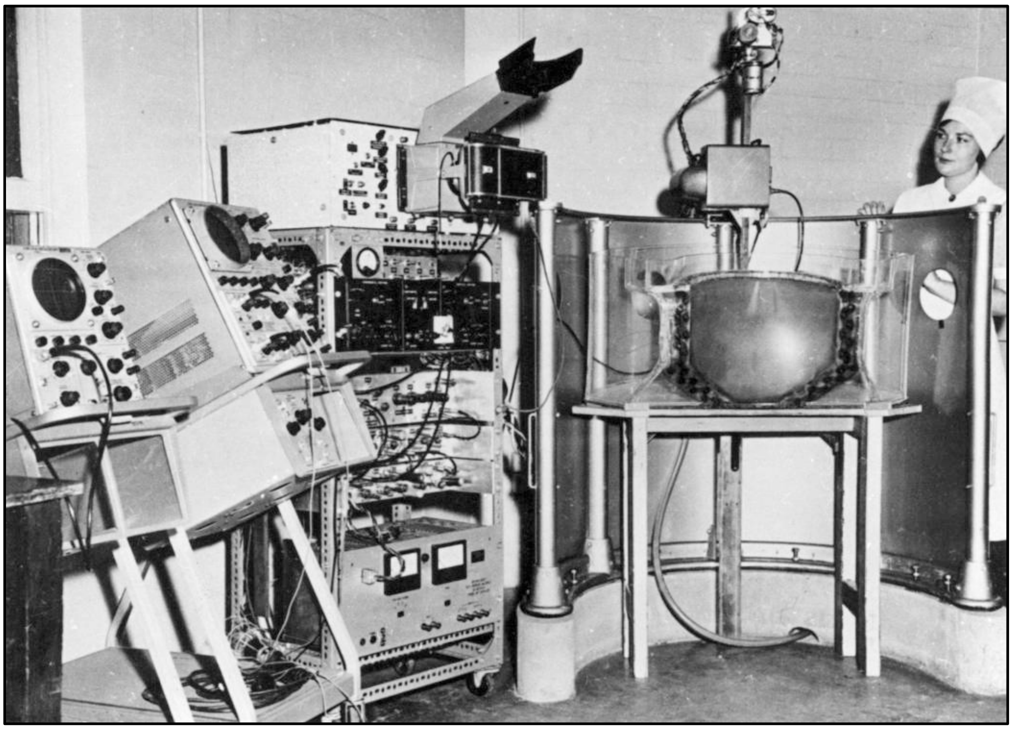
ULTRASONICS INSTITUTE AUSTRALIA
1959-1997



A short history of the Ultrasonics Institute (under its various titles) prepared for the historical display at the 2009 Congress of the World Federation for Ultrasound in Medicine and Biology, Sydney, Australia.

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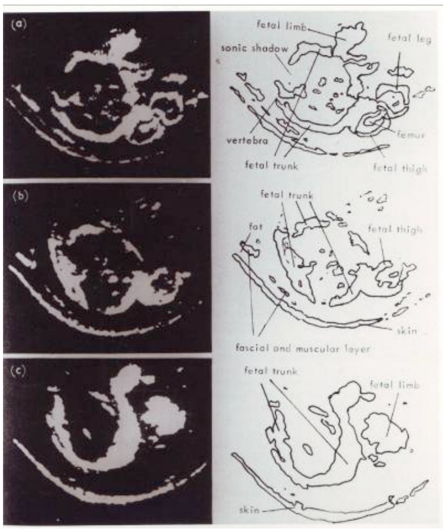
The Ultrasonics Institute went through a series of organisational changes during its life:

1959 – 1975: Ultrasonics Research Section, Commonwealth Acoustic Laboratories Branch, Commonwealth Department of Health.
1975: Became a separate entity.
1975 – 1989: Ultrasonics Institute Branch, Commonwealth Department of Health.
1989: Transferred to the CSIRO.
1989 – 1997: Ultrasonics Laboratory, Division of Radiophysics, CSIRO.

Prepared by Dr. David Robinson AM, with assistance from Dr. William Garrett, Dr. Rob Gill, Ms. Kaye Griffiths AM, Dr. Jack Jellins AM, Dr. George Kossoff AO, Prof. Thomas Reeve AC, CBE, Mr. Ian Shepherd, Dr. Laurie Wilson, and Dr. Peter Warren.

IN THE BEGINNING

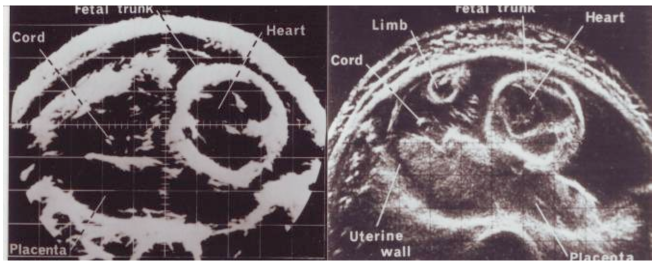
Ultrasonics research in Australia can be ascribed to the vision and foresight of Mr. Norman Murray, Director of the Commonwealth Acoustic Laboratory. On seeing a paper from Ian Donald from Glasgow, he wanted Australia to produce an imaging system for the pregnant uterus without ionising radiation. The Ultrasonics Research Section at the Laboratory was formed in 1959 with George Kossoff (Scientist), and Reg Allen and Laurie Lean (Technical Officers) with Dr. William Garrett (Obstetrician) providing the medical input. They commenced construction of a water delay compound scanner. Progress increased with the addition of David Robinson (Scientist) in 1961 and Ian Shepherd and George Radovanovich (Technical Officers) in 1962.



The first images were obtained in May 1962. George Kossoff presented them at an Ultrasound Meeting in Champaign-Urbana, Illinois, USA where three papers on imaging were presented. Initial progress was rapid, and by October, 1962 we were able to identify various intrauterine and intrafetal structures, while “competing” labs were struggling to tell the fetal head from the trunk. The next international exposure was at Pittsburgh, USA in 1965. To our delight our images were the clearest of those from the six labs presenting.

The major technical contributions during this early period were in transducer design and fabrication, scanner design requirements, and the recognition of ultrasonic artefacts. The clinical contributions were in the identification of fetal anatomy, recognition of the possibility of fetal surgery and the assessment of fetal well-being from ultrasonic size measurements.

GREY SCALE

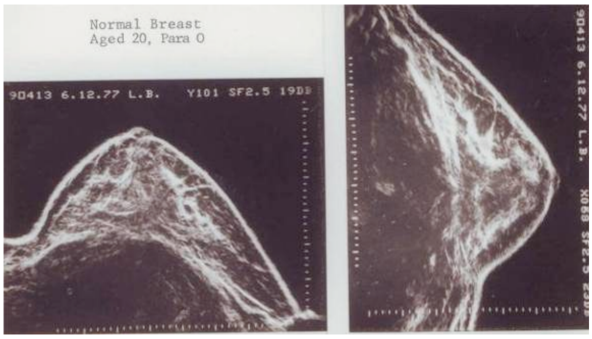


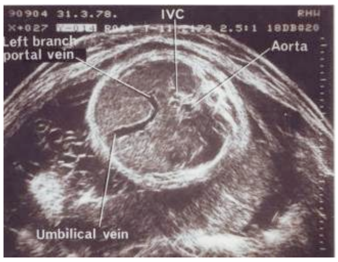
In 1969, there was a change in our display philosophy to concentrate on compressing the large echoes and using all the available dynamic range of the display system to display smaller echoes. The critical issue was transducer and electronics design to ensure that the spatial and temporal side lobes were reduced so that large specular echoes from tissue boundaries did not obscure the smaller parenchymal echoes. This development allowed the parenchymal echoes to be clearly seen, providing much soft-tissue detail. This made a spectacular improvement to the image content and clarity for diagnosis. The structure within organs could be appreciated including in the fetus, and the liver, kidneys, pancreas, breast and neonatal brain.

This display technique made it less important to display the outlines of organs, making a “keyhole view” practical and thereby paving the way for real-time scanning.

OCTOSON

Our original technique for compound scanning using a single transducer in a circular path took around 20 seconds per scan, making the entire multi-slice examination time consuming and sensitive to patient movement. To overcome this we designed a scanner with an arc carrying eight transducers which all scanned in synchronism. Each transducer was excited in turn before moving to the next angular position. Thus, each scan could be acquired in less than one second, when the arm was then automatically translated to its new scan plane. In this way a wide-angle view of the entire anatomy was obtained. This instrument was found well suited for examination of the pregnant uterus and abdomen, breast and neonatal brain.

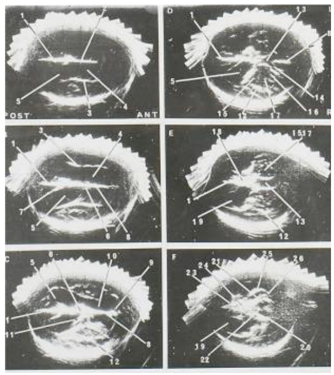




The device was commercialised by Ausonics, a company set up by the Nucleus Group for the purpose. From 1977 to 1982, approximately 200 were sold around the world, resulting in export income of $20M. A smaller system with four transducers was developed for the breast and around 100 were sold.

The advent of X-ray CT scanning dampened the demand for the Octoson. While CT was much more expensive it was not limited to soft tissue areas. The Octoson continued to be used as an ideal acquisition system for ultrasonic imaging research.

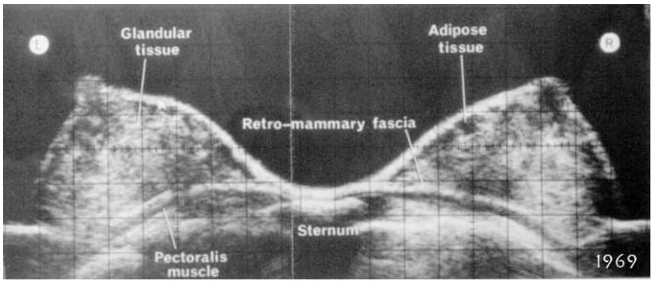
NEONATAL HEADS



In 1973, a fetus with ventriculomegaly was observed. The neonate was subsequently brought in for further examination. In consultation with radiologists at the Prince of Wales Hospital, 10 further patients were examined with both ultrasound and air ventriculograms, and all further patients were examined with ultrasound only, a great advance in patient safety! The initial paper submitted to a Neurology journal was rejected by the senior editor as CT Scanning would take over! At first the UI contact compound scanner was used, and later the Octoson. A comprehensive atlas of the brain of the neonate was published.

BREAST

Ultrasound breast imaging began in 1966 with the installation at the Royal North Shore Hospital of a dedicated water coupling breast scanner with Jack Jellins (Scientist), Brian Hill (Technical Officer) and Prof. Tom Reeve (Surgeon).



Clinical investigations began in 1967, and grey scale was implemented in 1969. The composite image of a 38 year old women obtained with grey scale demonstrates the wide range of echoes that could be displayed. With improvements in image quality, clinical reporting began in 1970. Further developments clearly displayed liquid filled structures, and demonstrated the different ultrasonic features in benign and malignant solid lesions. Through publications from the Institute with its clinical collaborators, UI played a major role in the establishment of breast ultrasound in Australia and internationally. Major achievements from the late 1960s to the end of the 1970s include: implementation of grey-scale image processing; image correlation with thick-thin anatomical sections; malignancies represented by low-level echo areas; classification of both liquid-filled and solid lesions; development of diagnostic criteria - primary and secondary features; vascularity assessment in combination with grey scale imaging. This progress triggered the formation of international breast ultrasound congresses and the International Breast Ultrasound School (IBUS).

DOPPLER

The initial focus of Doppler development was on using the Octoson for the measurement of the volume rate of blood flow rather than simply velocity. Existing methods for blood flow measurement were manual, inaccurate and only measured blood velocity. The first application was the measurement of umbilical cord flow as a measure of fetal well being. Later, the technique was used for evaluating the performance of adjustable portacaval shunts in the adult liver, a technique regularly employed until the widespread adoption of the TIPS procedure. An interesting applied Doppler project was an investigation of blood flow in the lower leg of the horse. The aim was to reduce lameness and to help develop better treatments for it.

Subsequently the Doppler work was redirected towards techniques suitable for real-time scanners. An important achievement was the development of an improved method of colour Doppler imaging. This was sold under licence to a leading equipment manufacturer and became the basis of their "second-generation colour" technology which is still used today.

OTHER PROJECTS

The successful "modus operandi" used in the original scanner was repeated for other applications. In each case, scientists and technical officers developed the equipment, and collaborated with an interested medical specialist to refine the imaging properties and evaluate applications. There were projects in eye, heart and brain with purpose built equipment and dedicated scanners for each area.

M-mode investigations in the heart led to the identification of a diagnostic appearance for the posterior leaflet of the mitral valve. This was not believed by the reviewers who rejected the paper, but is now used routinely.

Thyroid, Parathyroid and Scrotum: During the mid 70s, the water bath scanners were able to provide ultrasonic images of thyroid anatomy and demonstrate the presence of abnormal lesions. Parathyroid glands when enlarged could be visualized, and as a result ultrasound became an essential component in the diagnostic steps before parathyroid surgery. The equipment could be adapted to image the scrotum, and abnormalities such as seminoma were readily detected.

Tissue Characterisation: Tissue characterisation derives from ultrasonic echoes information about tissue pathology which cannot be seen in the grey scale images. UI pioneered several approaches to this problem using increasingly sophisticated signal and image processing and demonstrated clinical applications. Three approaches were developed at UI as described below:

- Attenuation in tissue was measured by the variation with depth of spectral slope. This technique was used in the liver, spleen and vascular tissues. The best correlation with pathology was found in intravascular scans of the vessel walls, in which non-fibrous plaque was highlighted with a colour overlay.

- The speed of sound was measured by registering images obtained from different directions with a multi-transducer scanner such as the UI Octoson. A significant reduction in sound speed was found with fibrosis, and used to demonstrate staging of haematological disease through measurements in the spleen.

- The way in which tissue moves and deforms under external or natural stimulus (e.g. the beating heart) can be used for detecting changes in compliance, associated with pathology. UI's pioneering work in this area contributed to the development in the USA of the now very significant research area of elastography.

Most of this work was ahead of its time, and did not lead to immediate commercial application. However, it strongly influenced research in many groups around the world, and commercial applications are now beginning to appear.

Bioeffects: UI had an ongoing program investigating the safety of ultrasound from the beginning. The initial research was concerned with development of dosimetry techniques. In this way the bioeffects studies undertaken by UI were supported by accurate dosimetry information. Studies on effects from B-Mode diagnostic exposures showed no effects on tissue. Techniques to implant small thermocouples in the organs of live fetal guinea pigs showed that a temperature elevation of several degrees can be obtained in tissue with pulsed Doppler and M-Mode exposures.

Safety Standards: Following the WFUMB'85 Congress in Sydney, the Institute, with funding support from WFUMB, staged three consecutive seminars on Safety and Standardisation of Medical Ultrasound. Leading international experts were invited to attend and, in the end, were able to achieve consensus on Safety Statements that were accepted by major ultrasound societies and international regulatory authorities. The data provided by the Institute played a major role in acceptance of the current Thermal Index.

Externally Funded Projects: Following the transfer to CSIRO, obtaining external funding became possible (and in fact an obligation!). A project undertaken for the Defence Department in collaboration with GEC-Marconi involved an underwater imaging system for visualising sea mines in turbid water, called AMI (Acoustic Mine Imaging). It involved a large 2-D sparse array in the MHz range to achieve a 1 mm resolution over a 1 metre cube of muddy sea water. A project undertaken for the Meat Research Corporation involved automated measurement of the cross-sectional area of the longissimus dorsi muscle (rib-eye steak) in beef cattle "on the hoof". It achieved results consistent with skilled human ultrasound observers. These projects suffered the Australian difficulty of obtaining venture capital to translate the research results to commercial products.

A tissue characterisation project, also for the Meat Research Corporation, to assess tenderness of meat in live animals was less successful, as treatment of the meat before and after slaughter had a large influence.

Funding for medical projects was obtained from some of the major international ultrasound manufacturers. Areas supported included Doppler flow measurement using real-time scanners, tissue aberration correction and intravascular tissue characterisation.

Ultrasound Surgery: In the 1960's an ultrasonic method for treating Meniere's Disease, originally developed in Italy, was improved technically. An ultrasonic applicator was developed for the lateral semi-circular canal which was much lighter than the overseas model and generated much less heat. This allowed the Meniere's symptoms to be alleviated without further loss of hearing. Later, an alternative approach was developed using a miniature transducer irradiating through the round window, removing the need for mastoidectomy.

PROFESSIONAL SOCIETIES

ASUM: When the formation of an Australian society for ultrasound was mooted, it was inevitable that that the Institute staff and collaborators would be heavily involved. The Society was formed in 1970, and all major office-bearers of the Society came from UI staff and their collaborators until 1978 when Dr. Ian McDonald, a cardiologist from Melbourne was elected Vice President, and subsequently President. The first three Annual Scientific Meetings were organised by Ultrasonics Institute staff and their medical collaborators. As commercial equipment became available, it was seen as appropriate for the UI staff and their medical colleagues to start an annual UI/Royal Hospital for Women Course, which began in 1978 and continued for 18 years until ASUM developed its own excellent education program and Universities began to offer courses for sonographers.

WFUMB: Concurrently with the formation of ASUM, talks were held in the international sphere for the formation of the World Federation for Ultrasound in Medicine and Biology. In 1973 WFUMB was finally formed, complete with the Journal "Ultrasound in Medicine and Biology" and regular Congresses. George Kossoff was elected Vice-President from 1969 – 1982, and President from 1982 until 1985, William Garrett Vice-President from 1985 until 1991, David Robinson Secretary from 1985 until 1994 and then a Vice President until 1997. Stan Barnett was Secretary from 2003 until the present.

WORLD FEDERATION OF SONOGRAPHERS (WFS): was formed in 1985 with UI staff member Ms. Kaye Griffiths as foundation President.

Smithsonian Institute, USA: In conjunction with WFUMB 1988 in Washington DC a History Symposium was held at which seven UI staff members attended and four gave presentations or chaired sessions.

EDUCATION

As the focus of ultrasound knowledge and experience in Australia, UI trained many medical specialists in this new modality. Initially, this was by the "apprenticeship" system, where Medical Specialists in fields such as ObGyn, Nuclear Medicine and Radiology would spend up to three months at the Institute, learning ultrasound physics and visiting the various clinical areas. As the demand increased, a formal course was arranged, with fees charged. These funded administrative expenses such as the preparation of course materials and also allowed overseas lecturers to be invited. This gave participants access to international developments, and also showed to the participants and overseas lecturers that ultrasound in Australia was at a high standard. The Institute provided joint supervisors for many PhD and Masters Degree students, and hosted international exchange visitors.

STAFF AND MEDICAL COLLABORATORS

That such a small group had the impact it did on the development of medical ultrasound imaging was somewhat remarkable. It can be put down to good people working as a team over an extended period. The scientists and technical officers were sufficiently innovative and well funded to use the latest electronic and display components, and they were kept "on the straight and narrow" by our excellent and innovative medical colleagues.

A leading US medical scientist when commenting on the UI role said: “We were continually frustrated to be unable to obtain your transducers and equipment, but you became the ‘existence theorem’. If you could achieve some milestone, it proved it was possible and we set about to follow”.

It is remarkable that, for this small group in a specialised field, not only was international scientific recognition forthcoming, but also recognition at the public national level. The UI work was commemorated by the issue by Australia Post of a stamp in the “Australian innovation” series in 2004. Among the scientific and sonographer staff and medical collaborators there are 11 recipients in the Order of Australia; one Companion of the Order (AC), four Officers (AO), and six Members (AM).

MEDICAL COLLABORATORS

There were a large number of medical collaborators, including:

Dr. W.J. Garrett AM	Obstetrics & Gynaecology	Royal Hospital for Women
Dr. H.L. Hughes AM	Ophthalmologist	Royal Prince Alfred Hospital
Prof. T.S. Reeve AC, CBE	Surgeon	Royal North Shore Hospital
Dr. C.C. Fisher	Obstetrics & Gynaecology	Royal Hospital for Women
Dr. R. Picker	Obstetrics & Gynaecology	Royal North Shore Hospital
Prof. D.E.L. Wilcken	Cardiologist	Royal Prince Henry Hospital
Dr. P.S. Warren	Radiologist	Royal Hospital for Women
Dr. B.D. Doust	Radiologist	St. Vincent’s Hospital
Dr. J. Croll AO	Breast Physician	Sydney Square Breast Clinic
Dr. M.B. Kossoff	Radiologist	BreastScreen
Prof. M.J. Edwards AO	Veterinarian	Sydney University
Prof. B.H. Barraclough AO	Surgeon	Royal North Shore Hospital
Dr. M. Appleberg	Vascular Surgeon	Royal North Shore Hospital
Dr. E.F. Crocker	Nuclear Medicine Physician	Westmead Hospital

Staff Photo 1979

Back Row: G. Radovanovich, B. O’Connor, I. Shepherd, S. Barnett, J. Jellins, D. Robinson
Middle row: M. Dadd, G. Kossoff, D. Carpenter, R. Gill, P. Knight, L. Wilson, G. Lange, P. Isaacs, R. Hanlon, K. Griffiths.
Front Row: S. Barnstable, M. Tabrett, M. Moriaty, J. Irani.

UI/RHW Luminary Course Speakers

Barbara Carroll (USA)
David Cosgrove (UK)
Roy Filly (USA)
Art Fleischer (USA)
Morimichi Fukuda (Japan)
Barry Goldberg (USA)
Ed Grant (USA)
Soren Hanke (Denmark)
Hans Henrik Holm (Denmark)
Alfred Kratochwil (Austria)
Michel LaFortune (Canada
George Leopold (USA)
Ted Lyons (Canada)
Larry Mack (USA)
Mike Manco-Johnson (USA)
Chris Merritt (USA)
Heidi Patriquin (Canada)
Phil Ralls (USA)
Fred Sample (USA)
Ken Taylor (USA)
Olaf von Ramm (USA)
Francis Weill (France)

UI/UL Lecturers

As the Ultrasonics Laboratory was winding down, the remaining funds from the UI/RHW course were transferred to ASUM to provide a keynote lecturer at the Annual Scientific Meeting. These were:

2002 Dr. Albert Lam
2003 Dr. John Newman
2004 Dr. Rita Teele
2005 Prof. Rob Gibson
2006 Prof. David Ellwood
2007 A/Prof. Jon Hyett
2008 A/Prof. Anthony Doyle

SIGNIFICANT DATES

1962	Transducers	G. Kossoff.
1962	Abdominal Echoscope	D. Robinson, G. Kossoff, G. Radovanovich, W. Garrett (RHW).
1966	Breast Echoscope	J. Jellins, G. Kossoff, T. Reeve (RNSH).
1966	Recognition of Artifacts	D. Robinson.
1967	Eye Echoscope	M. Dadd, D. Robinson, G. Kossoff, H. Hughes (RPAH).
1967	Mk 2 Abdominal Echoscope	D. Robinson, G. Kossoff, G. Radovanovich, W. Garrett (RHW).
1969	Grey Scale	G. Kossoff, D. Carpenter, M. Dadd, J. Jellins.
1972	Section authorised to provide "research and advisory services" under National Health Act.	
1973	Baby's heads	G. Kossoff, M. Tabrett, K. Griffiths, W. Garrett, P. Warren.
1973	Mini-computer installed	D. Robinson, B. Williams.
1974	Annular Phased Array	G. Kossoff, D. Robinson, G. Radovanovich, I. Shepherd.
1975	Ultrasonics Institute formed as separate Branch of Commonwealth Dept. of Health.	
1975	UI Octoson	G. Kossoff, D. Robinson, D. Carpenter, I. Shepherd, G. Radovanovich.
1977	Ausonics Octoson	
1979	Doppler	R. Gill.
1989	Ultrasonics Institute transferred to CSIRO and renamed Ultrasonics Laboratory.	
1990	Sponsored research for Defence Dept. in collaboration with GEC-Marconi to develop a 1 mm resolution 3D imager for imaging sea-mines in turbid water.	
1992	Sponsored research for Meat Research Corporation.	
1995	Aberration correction for overlying tissue	D. Carpenter, Y. Li.
1996	Doppler imaging system licensed to Philips for use in their commercial equipment.	
1997	Staff split between CSIRO Marsfield and Lindfield; the end of a unified ultrasound operation.	

SELECTED REFERENCES

The following references have been selected because of their impact on subsequent clinical practice. A comprehensive list of publications can be found in the History section of the ASUM web site (see page 12 for link).

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Links to websites of interest

http://www.powerhousemuseum.com/

http://www.asum.com.au (follow the link to the History section)