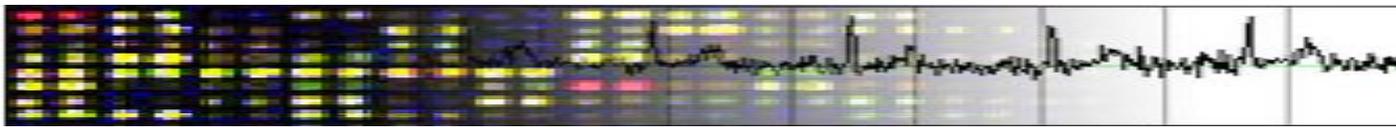# Biomedical Information Technology

2.771J   BEH.453J   HST.958J   Spring 2005
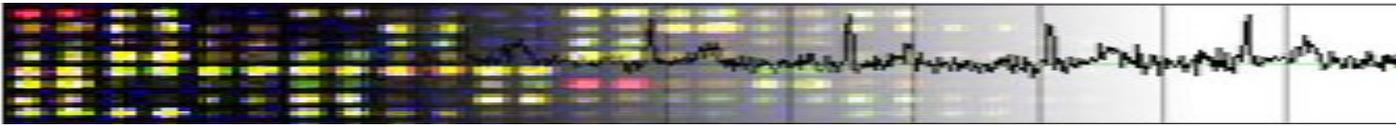
Lecture 10 March 2005

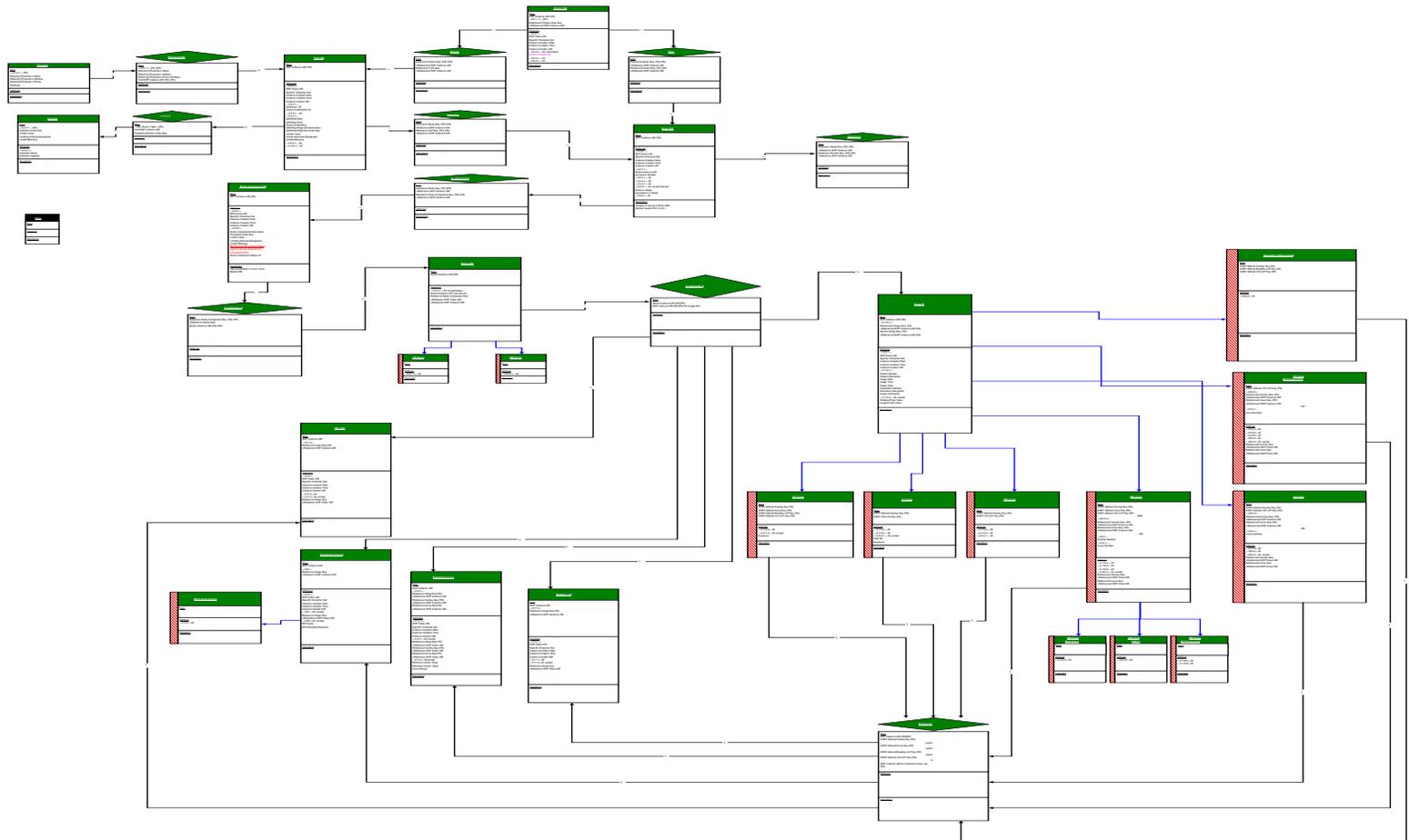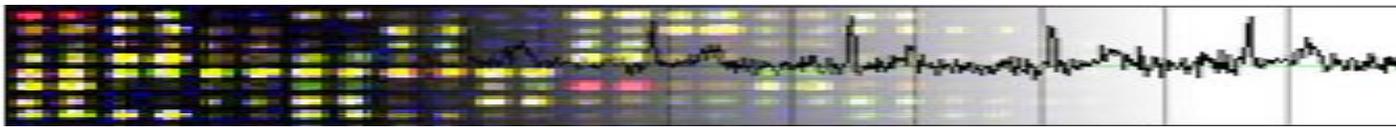# Microarray Information I

Microarray Information I

❖ *Implementation examples*

  ➢ A DICOM database repository

  ➢ A commercial image archiving system

❖ *Compression*

❖ *Integration of metadata into the images*

❖ *Integration of images into the
    healthcare environment*

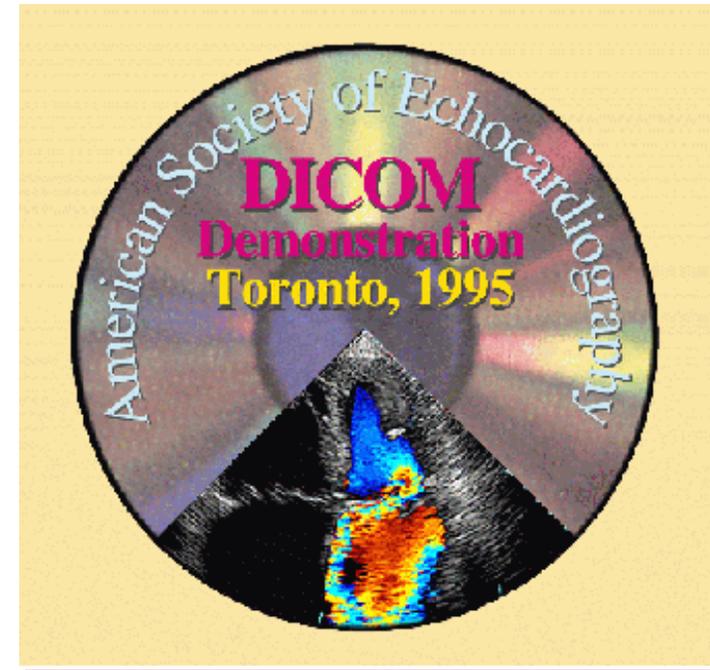❖ *Beyond databases: structured reporting*

An object-oriented DICOM database
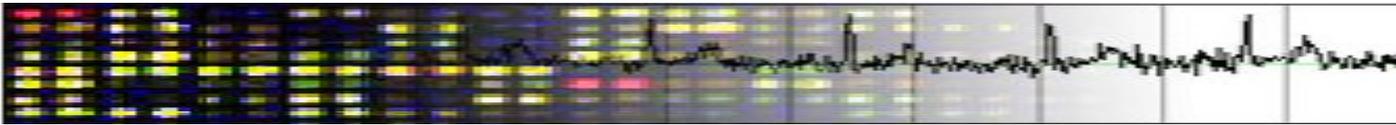

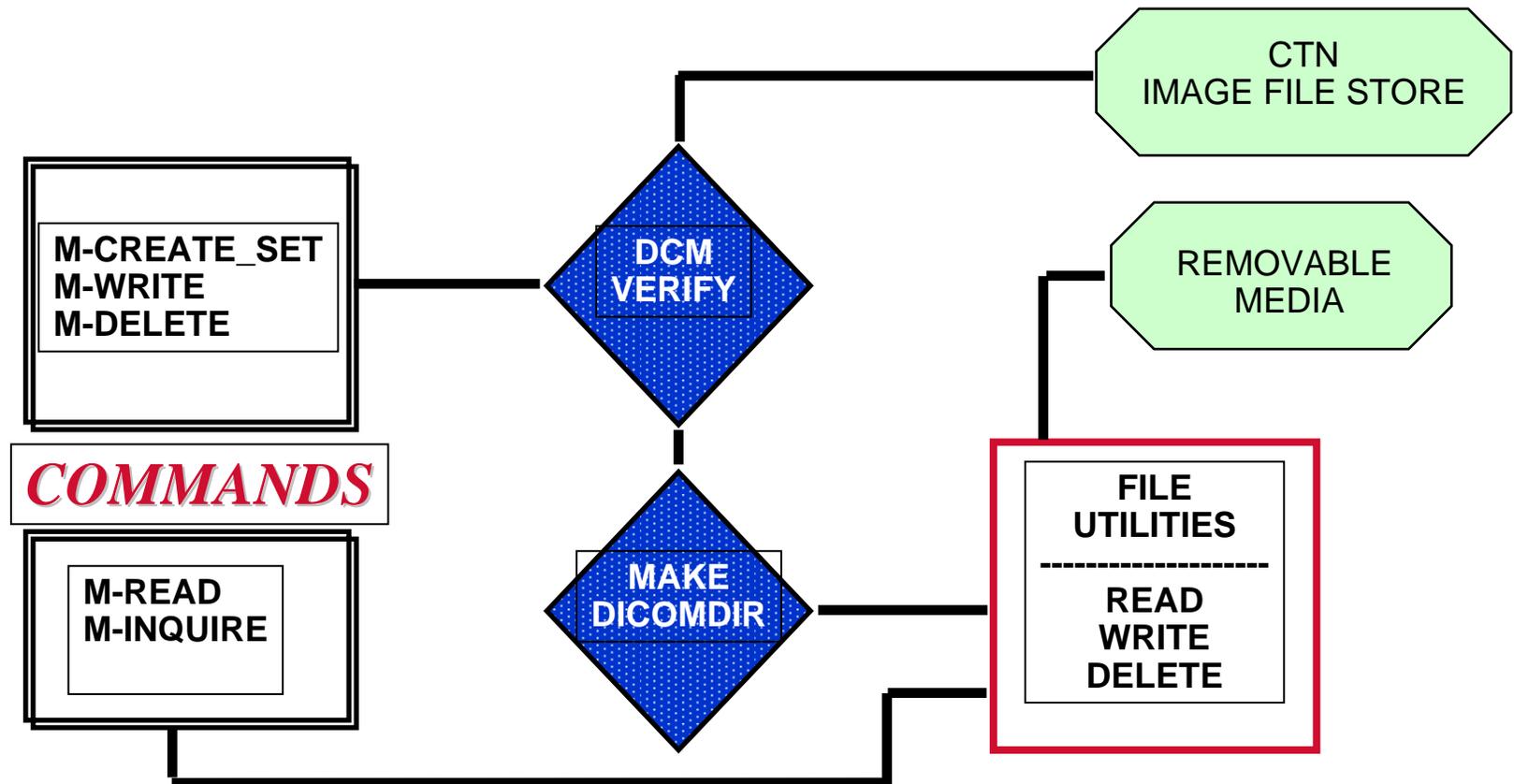*Ref: Ngon Dao, M.S. Thesis, MIT, 1998*

Implementation For Ultrasound

❖ ICMIT Chosen to Implement DICOM-3 Conformance Standard for Ultrasound

❖ Demonstration at American Society for Echocardiography Meeting in Toronto, June, 1995

❖ MO Disks, Floppy Disks, CD-ROM

❖ Sponsors:

Acuson	Toshiba
Hewlett Packard	TomTec
Vingmed	ATL/Interspec
Eastman Kodak	Biosound

❖ Further Efforts With Other Image Types:
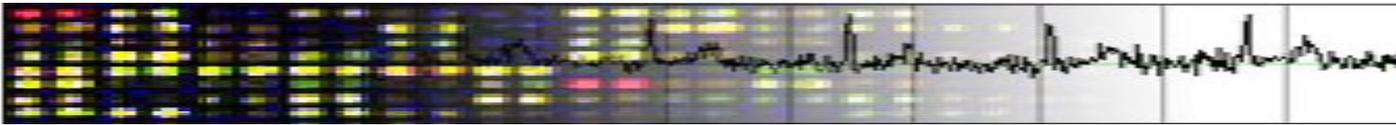Euro. Cardio. Cong. '95, Am. Coll. Cardiol. '96, Am Nuc. Soc. 96, ...

Courtesy of NEMA (National Electrial Manufacturers Association).
Used with permission.

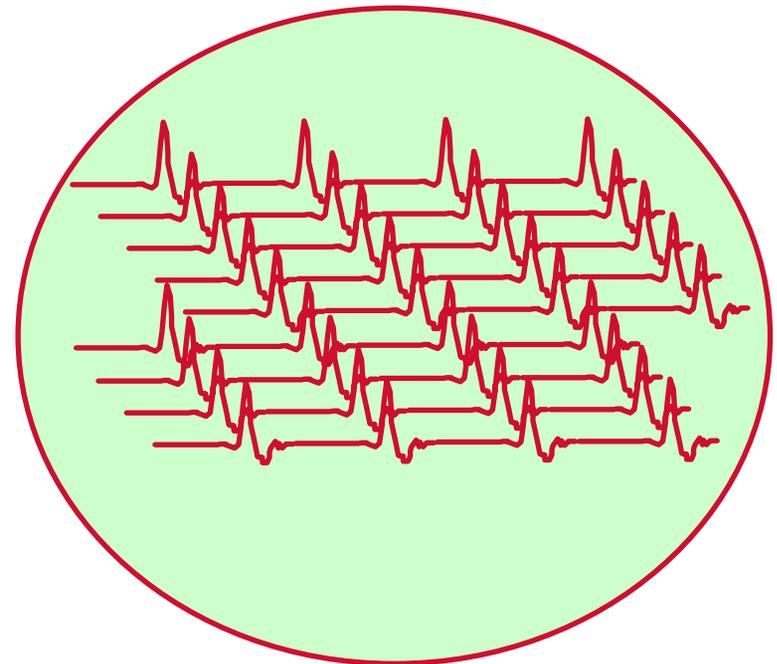# The ICMIT ASE (ultrasound) server architecture

CTN
IMAGE FILE STORE

M-CREATE_SET
M-WRITE
M-DELETE

COMMANDS

M-READ
M-INQUIRE

DCM
VERIFY

REMOVABLE
MEDIA

MAKE
DICOMDIR

FILE
UTILITIES
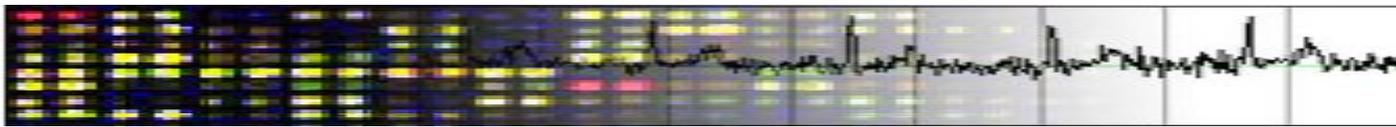--------------------
READ
WRITE
DELETE

© **cfdewey 2005**

Other image "waveform" modalities

- ❖ECG
- ❖EEG
- ❖Pathology
- ❖Endoscopy
- ❖Pulmonary Sounds
- ❖Laboratory Images
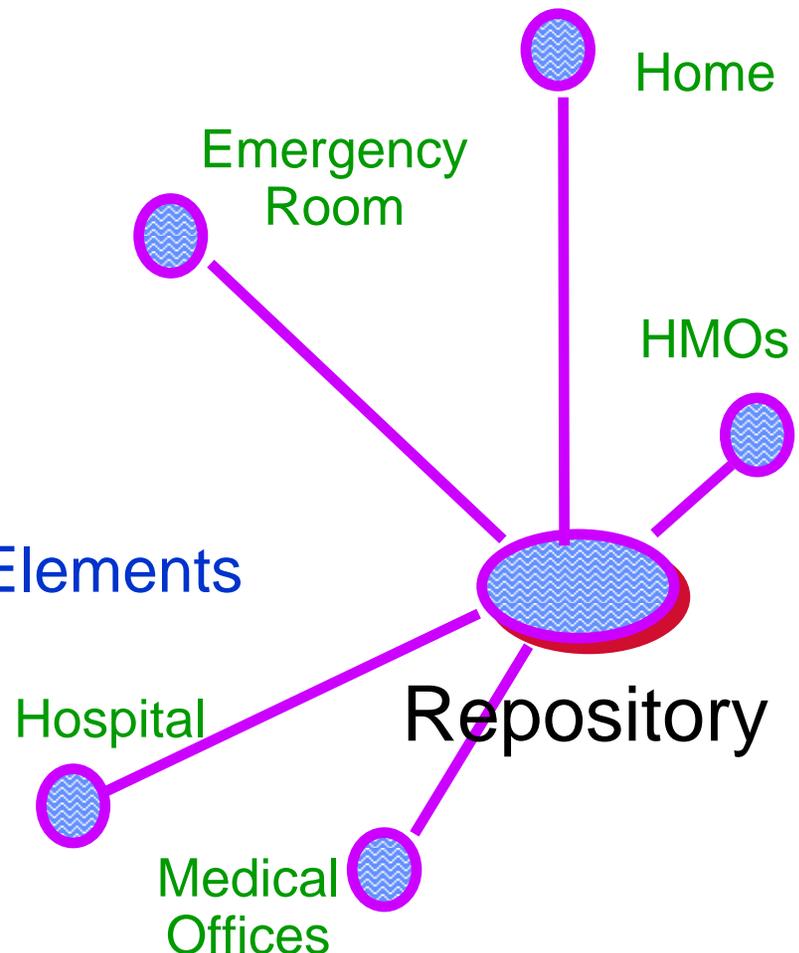- ❖Photographs
- ❖DNA sequences
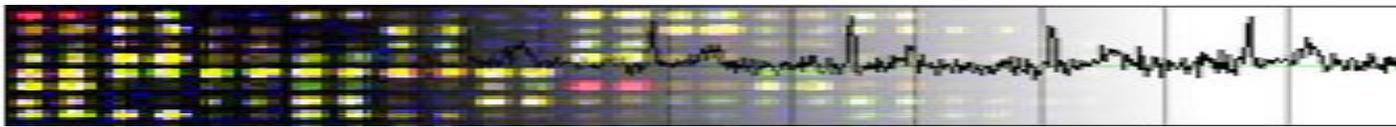- ❖Chromatography

See ECG "White Paper"

An Example of a New Modality: ECGs

❖ Use Existing DICOM Information Modules
  - ➢ Patient
  - ➢ General study
❖ New Elements Defined for Proposed ECG Standard
  - ➢ ECG series
  - ➢ ECG equipment
  - ➢ ECG group
  - ➢ ECG interpretation

72 Elements

❖ Display Over a Network
❖ Client-Server Architecture

Home

Emergency Room

HMOs

Repository

Hospital

Medical Offices

Integration of metadata: An example of a Structured Report (SR)

Chest X-ray Report:
Observer: Clunie^David^A^Dr.
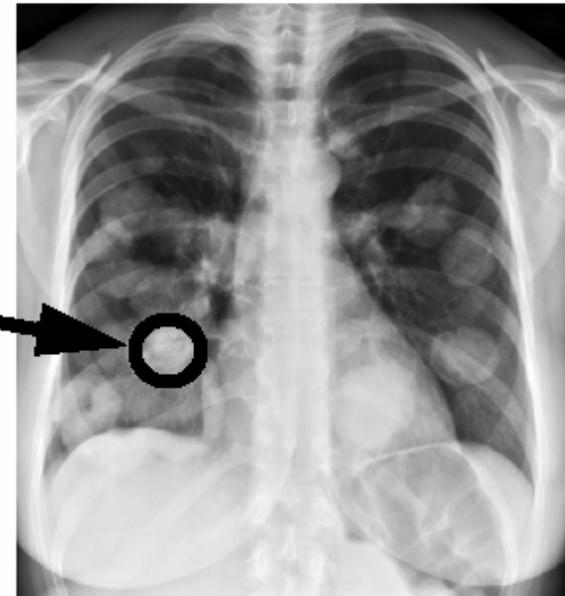History: malignant melanoma excised 1Y
Findings:
- finding: multiple masses in both lung fields
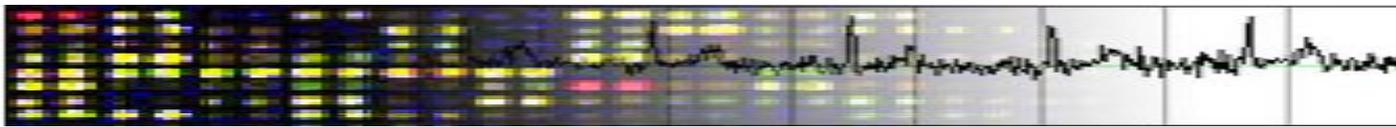- best illustration of findings:
Conclusions:
- conclusion: cannon-ball metastases
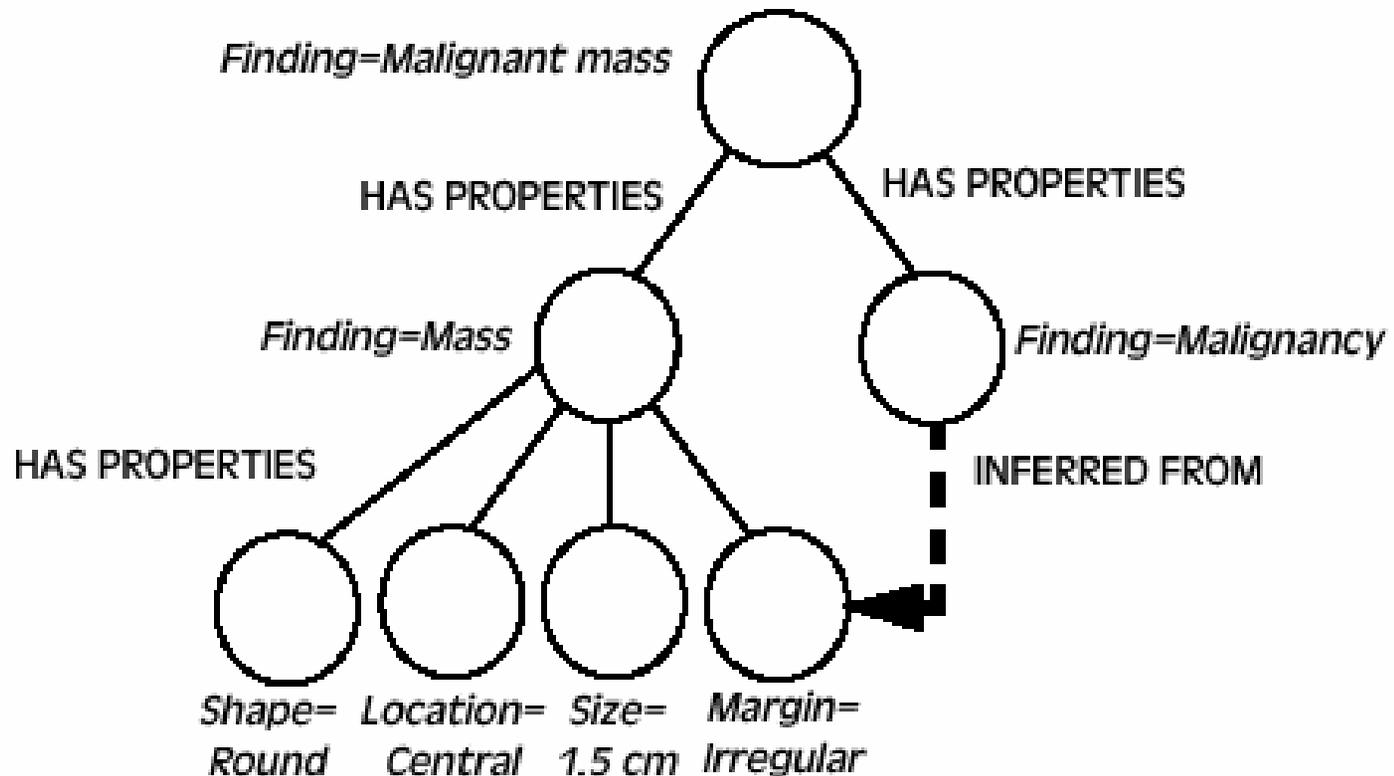- conclusion: recurrent maligant melanoma
Diagnosis Codes:
- diagnosis: 172.9/ICD9
- diagnosis: 197.0/ICD9

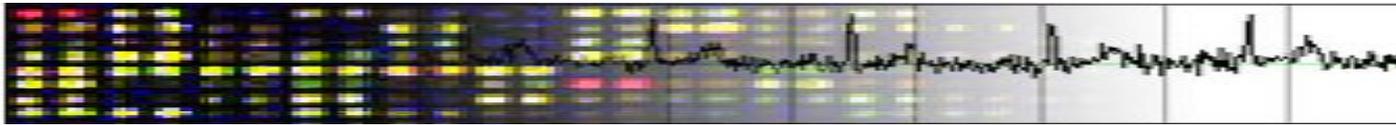*Ref: David A. Clunie, DICOM Structured Reporting, PixelMed Publishing, 2000, p 30*

Courtesy of Dr. David Clunie. Used with permission.

An SR tree with references (directed acyclic graph)

Finding=Malignant mass

HAS PROPERTIES   HAS PROPERTIES

Finding=Mass   Finding=Malignancy

HAS PROPERTIES   INFERRED FROM

Shape= Location= Size= Margin=
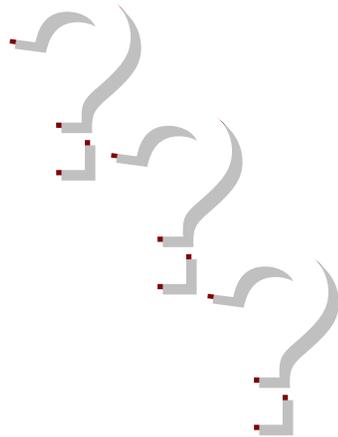Round Central 1.5 cm Irregular

Courtesy of Dr. David Clunie. Used with permission.
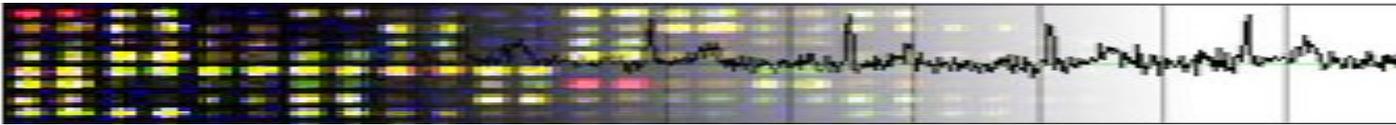
Ref: David A. Clunie, DICOM Structured Reporting,
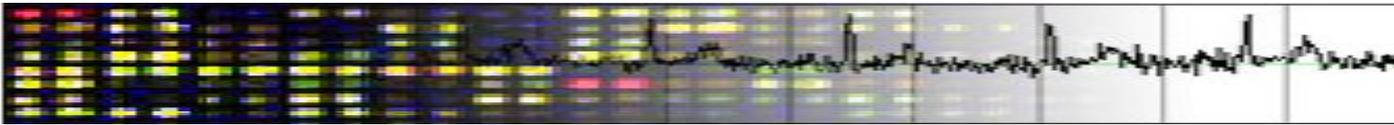*PixelMed Publishing, 2000, p 33*

Compression

❖ Why Compression?
  - ➤ Less storage
  - ➤ Less network bandwidth
  - ➤ Faster delivery and analysis

❖ What Methods Are Available?
  - ➤ Lossless: Lempel-Ziv, JPEG
  - ➤ Lossy: pyramidal, JPEG, JPEG 2000, wavelet, MPEG
  - ➤ Feature encoding

❖ What Are The Applications?
  - ➤ All general clinical use
  - ➤ Telemedicine

❖ What Are the Clinical Results?

  - ➤ Excellent!

Basic Information Theory

❖ Redundancy Facilitates Compression

➢ Remove redundancy without reducing information content

➢ Spatial, temporal, and chromatic redundancy

❖ Entropy is a Measure of Randomness

❖ Entropy Provides a Measure of Compressibility:

Ref: T. Gillespie III and A. Rowberg, J. Digital Imaging 1994:7, 1-12

Still Images: General Features
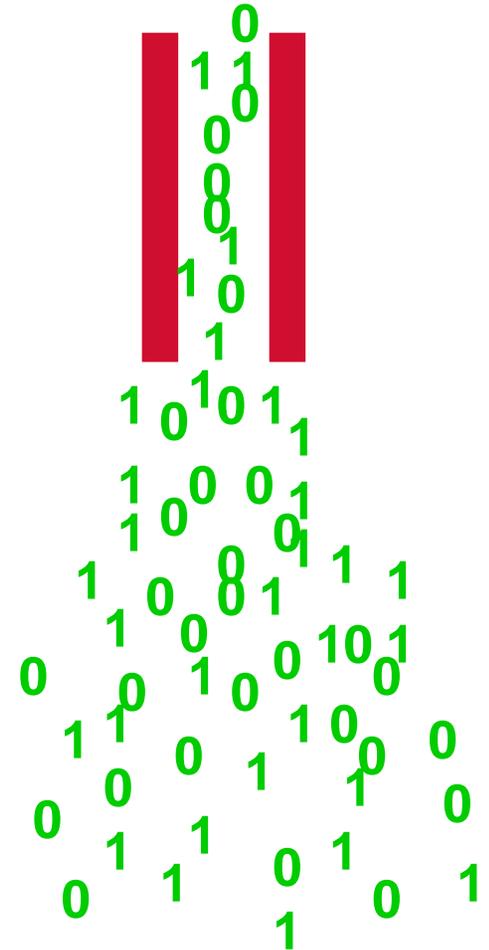
❖Lossy vs. Lossless
➢Lossless compression limited to ~1.5:1 to ~4:1
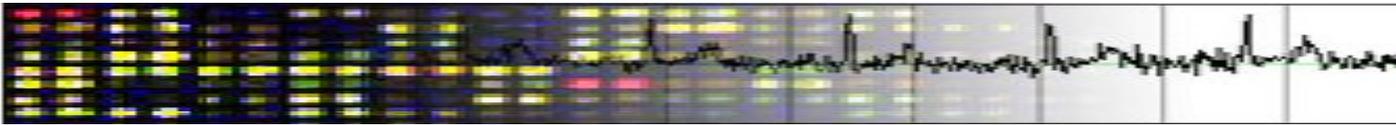➢Lossy compression can go much higher

❖Compression/Decompression Times
➢Larger times for more successful methods
➢Larger compression often means shorter decompression
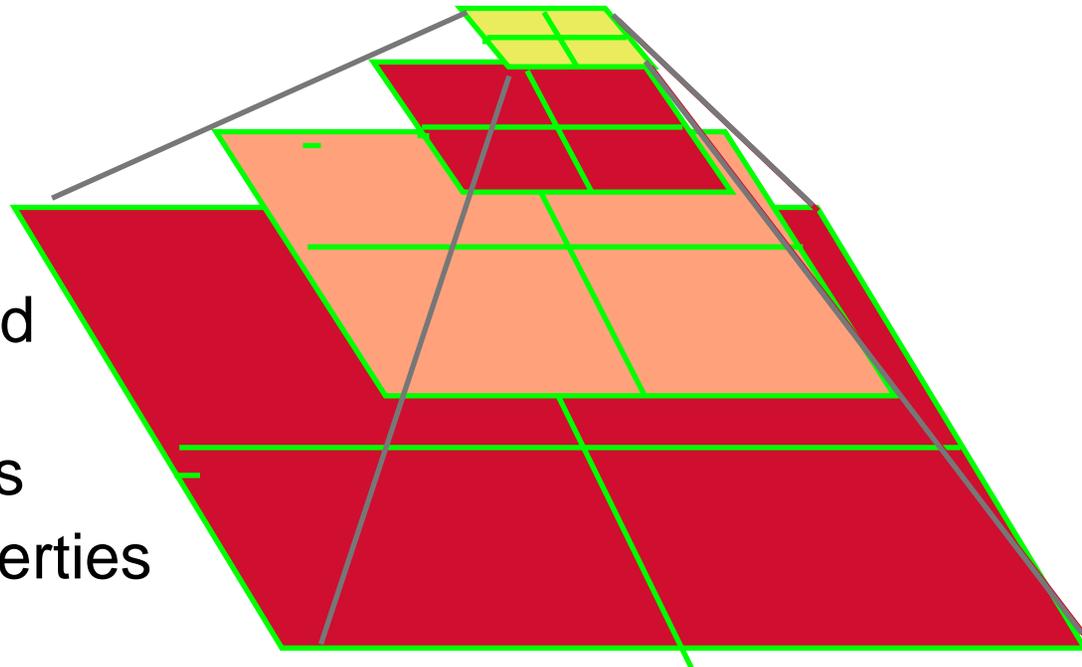➢Symmetrical vs. asymmetrical compression

❖General Applicable Methods
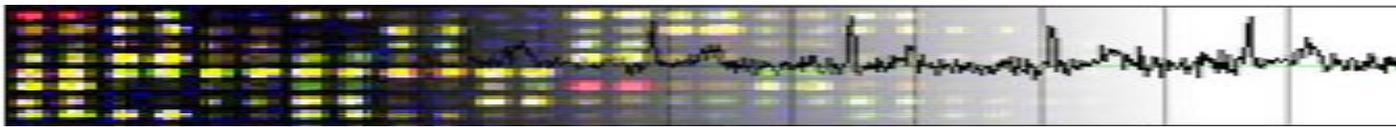➢Run-length encoding
➢Lempel-Ziv
➢Pyramidal
➢JPEG
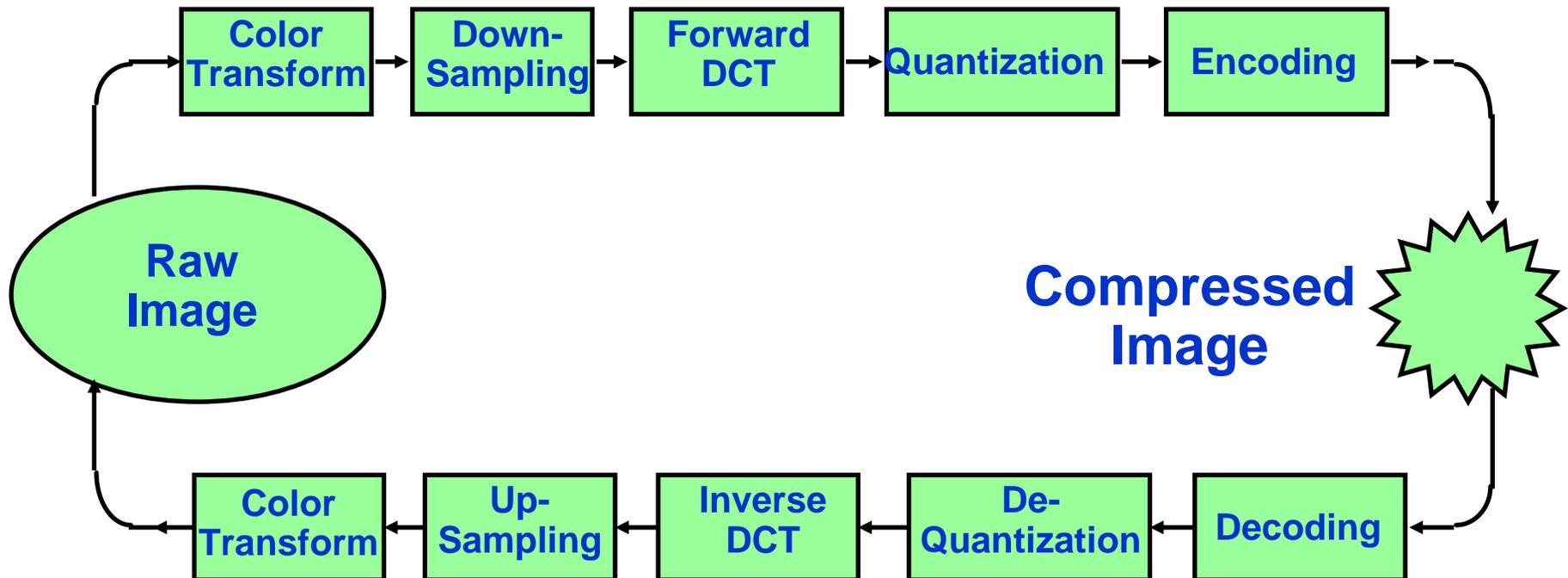➢Wavelet

Pyramidal Compression

- ❖ Originated With Granlund in "70s
- ❖ Broad exposition by Burt and Adelson ('82)
- ❖ Number of coefficients *Increases*
- ❖ Lossless until various scales are either individually compressed or deleted
- ❖ Forerunner of Wavelets
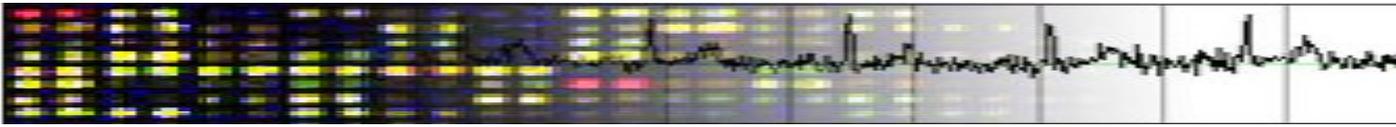- ❖ Can be used with properties other than scale

JPEG Compression

- ❖ Uses intraframe block Discrete Cosine Transform (DCT)
- ❖ Compresses color more than intensity
- ❖ Specified in the DICOM file format
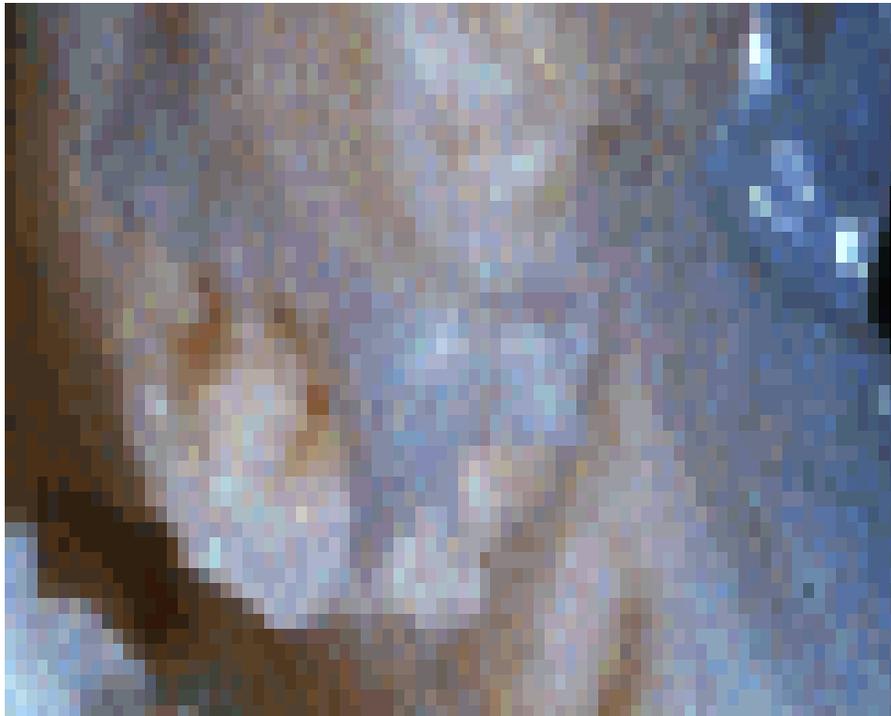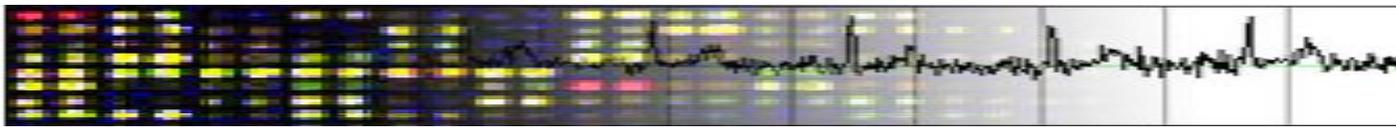- ❖ Can be "tailored" to fit many situations

```
Color Transform → Down-Sampling → Forward DCT → Quantization → Encoding
```

Raw Image

Compressed Image

```
Color Transform ← Up-Sampling ← Inverse DCT ← De-Quantization ← Decoding
```

© cfdewey 2005

An example of JPEG compression

Original   **Compressed 35:1**

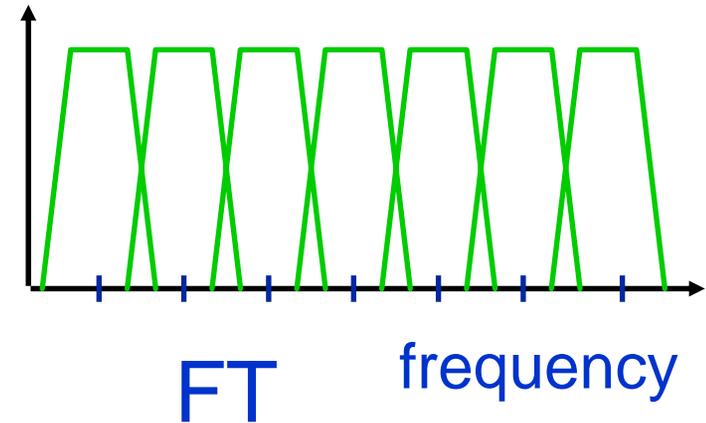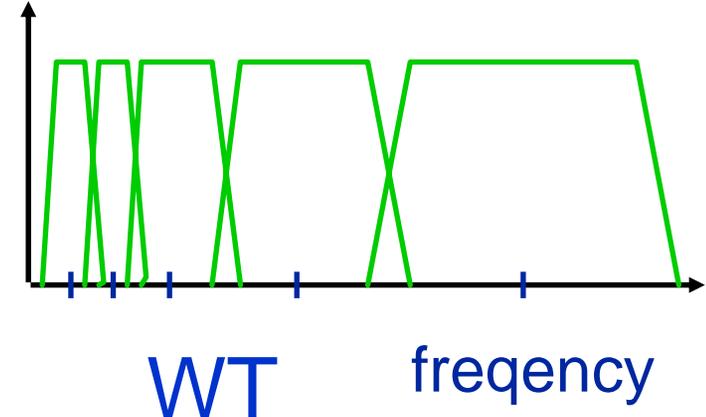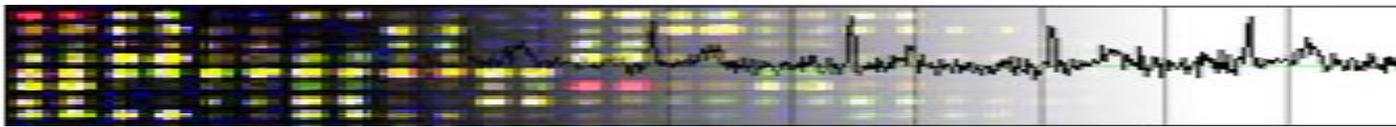# Wavelet compression

❖ Related to sub-band coding

❖ Potential advantage in having more information in some frequency bands than others

❖ Both public-domain and proprietary algorithms

❖ The basis of JPEG 2000

❖ Results of >20:1 have been obtained

❖ JPEG 2000 supports progressive transmission and region of interest (ROI) coding

Constant Bandwidth

FT   frequency

Constant Relative Bandwidth

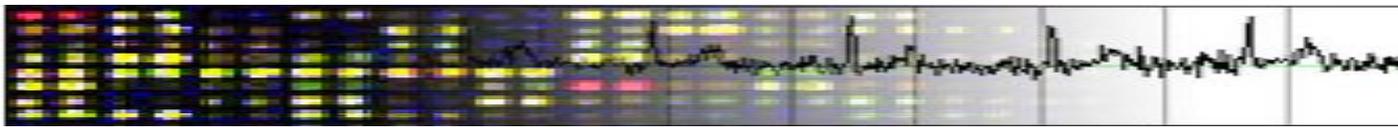WT   freqency

Wavelet Transform

Original image

Wavelet Transform - 5 Levels

Image removed for
copyright reasons.

Image removed for
copyright reasons.

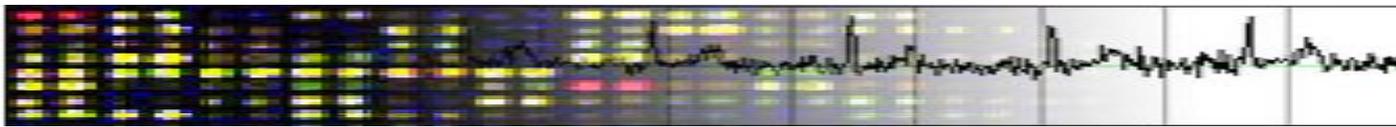*From Erickson, BJ et al. Radiology 1998;206:599-607*
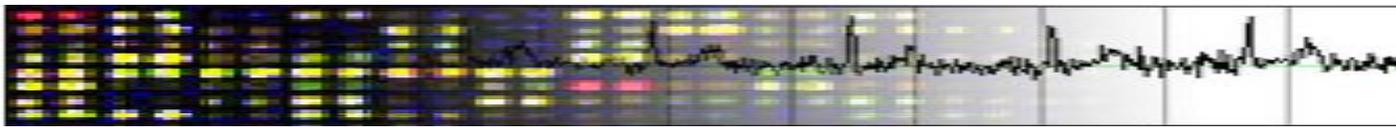
Another compression example

JPEG

JPEG 2000 (Wavelet)

Clinical compression trials

❖ Trials using JPEG and Wavelet technology

➤ JPEG used in ultrasound film loops and still images

▪ *Ref: Karson et al., Computers in Cardiol. 1993: 831-834*

➤ Wavelets used in CT, MR, and radiographs

▪ *Ref: Goldberg et al., AJR 1994:163: 463-468*

❖ JPEG images superior to video tape for US at a compression ~ 20:1

➤ "In the clinic, most US exams are stored on and read from video tape. Direct digitization of the original image prior to storage provides superior archive. It allows JPEG or other compression." *Karsten et al., 1994 AJR 163:463-468*

❖ Interframe compression for moving images, 3-D

➤ Significant delays while fiduciary frames are created

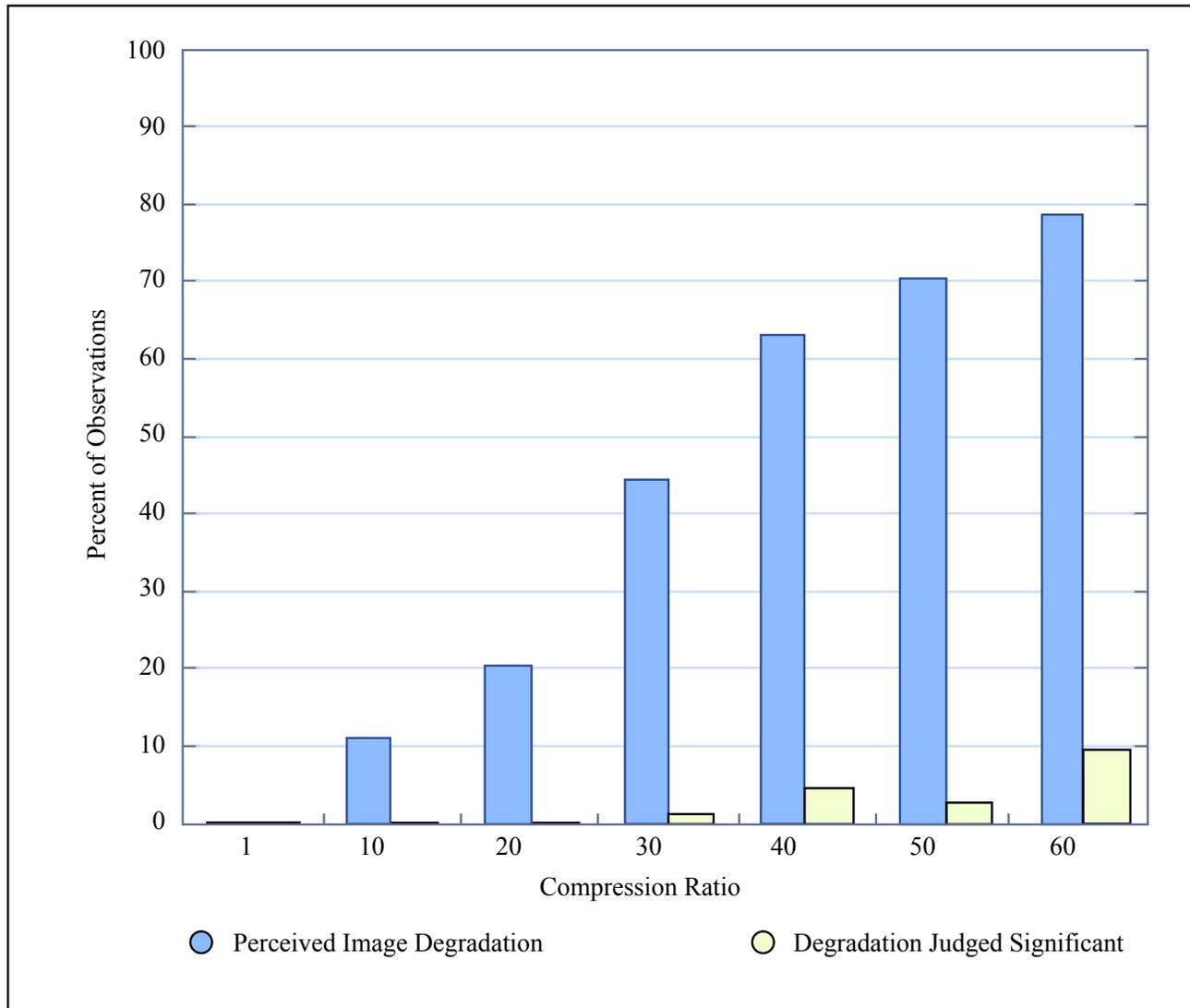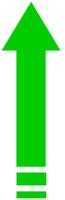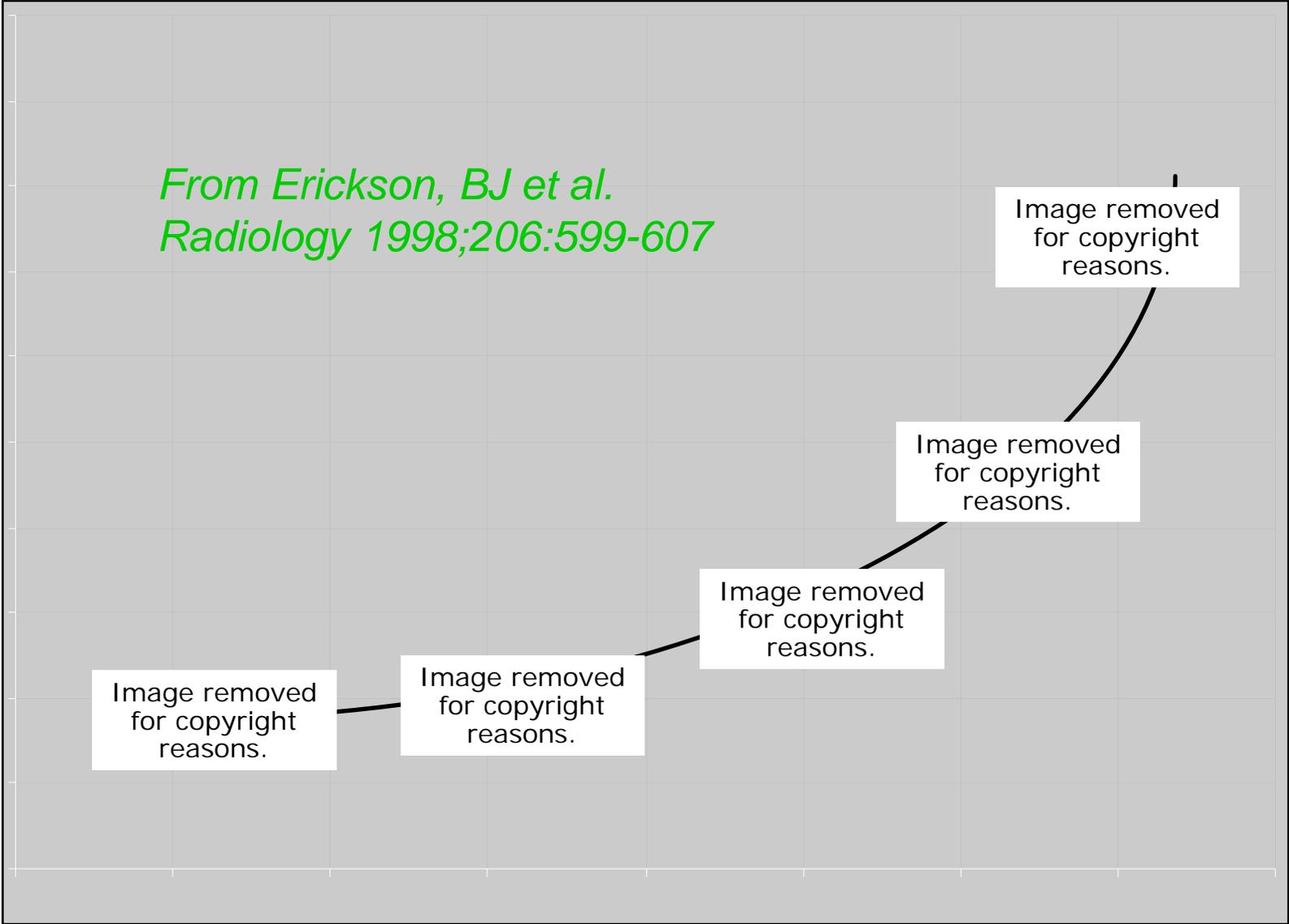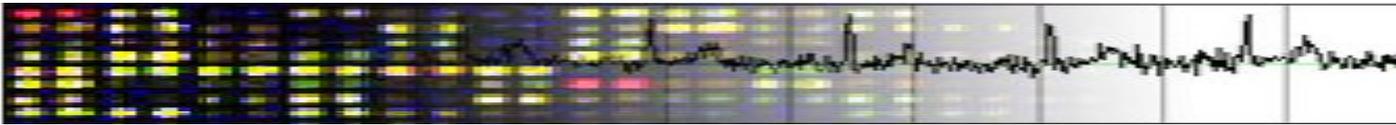# Significance of Perceived Radiograph Degradation

Figure by MIT OCW.

Effect of image content on compression

*From Erickson, BJ et al.
Radiology 1998;206:599-607*

Image removed
for copyright
reasons.

Image removed
for copyright
reasons.

Image removed
for copyright
reasons.

Image removed
for copyright
reasons.

Image removed
for copyright
reasons.

Maximum Compression Ratio

% Energy in Low Band

Integration into healthcare