Digital Imaging

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Learning Objectives

- Understand differences between analogue and digital imaging
- Know different types of imaging sensors
- What are advantages & disadvantages of digital imaging?

Recommended Textbooks

Essentials of dental radiography and radiology 5th edition
by Whaites, Eric; Drage, Nicholas
Churchill Livingstone 2013

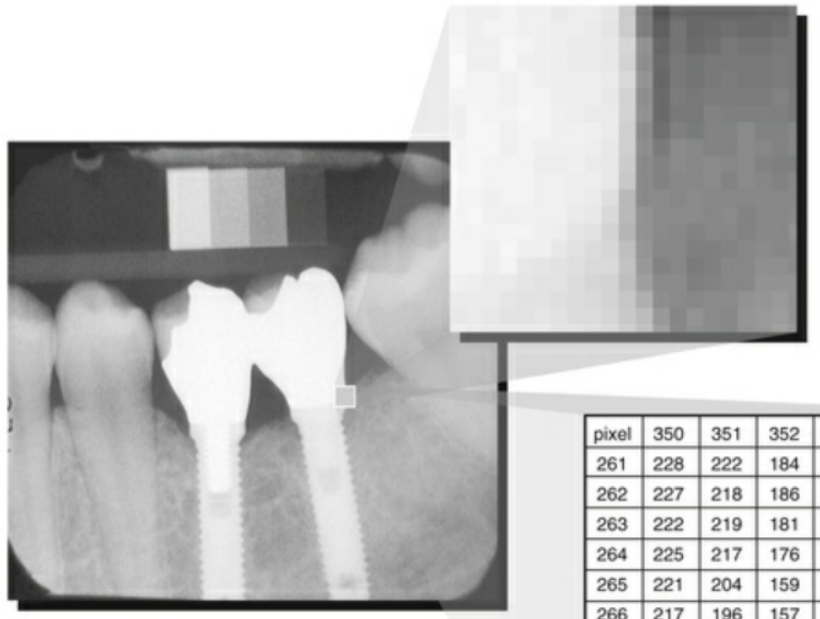
Pocket atlas of dental radiology
by Pasler, Friedrich A; Visser, Heiko
Flexibook, 2007

Oral radiology: principles and interpretation 7th edition
by White, Stuart C; Pharoah, M. J
Permalink 2014
- 8th edition available now

Analogue vs Digital

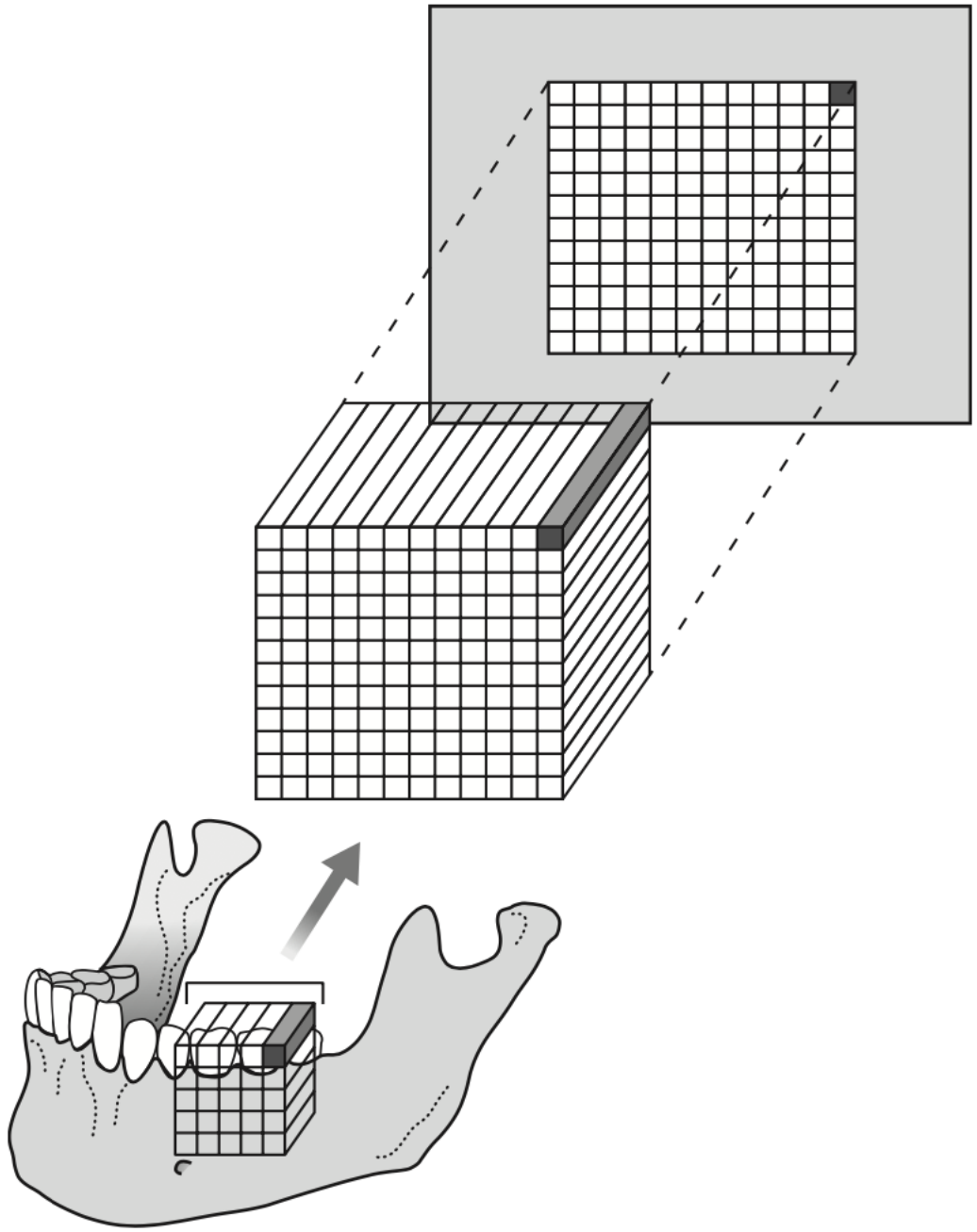
- Film vs Digital Receptors
- Processing
  - Chemical vs Electronic, time, health & safety, …
- Storage & Transfer
- Image display
- Image resolution
  - Analogue = continuous density spectrum
  - Digital = numeric format of the image content and its discreteness
    - Pixels
    - At each pixel of an electronic detector, the absorption of x-rays generates a small voltage
- Dosage
- Others
  - Cost, image enhancement, etc.

Pixels



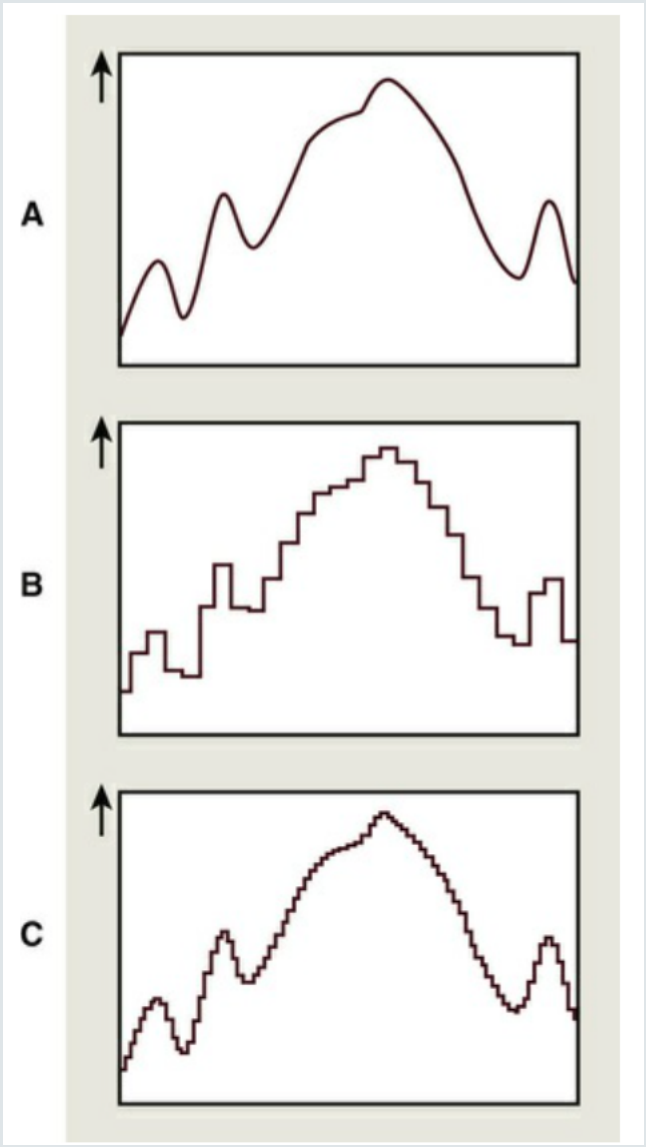
pixel	350	351	352	353	354	355	356	357
261	228	222	184	107	76	92	90	98
262	227	218	186	110	90	104	103	98
263	222	219	181	107	97	107	102	104
264	225	217	176	107	98	100	100	107
265	221	204	159	107	105	101	107	102
266	217	196	157	114	105	104	106	100
267	209	190	154	114	107	103	97	100
268	202	195	166	118	102	102	92	94
269	197	196	168	122	98	102	90	94
270	195	190	166	130	104	105	92	97
271	199	190	172	144	111	107	100	106
272	201	193	177	160	120	103	112	106
273	203	195	181	166	129	102	111	106
274	201	200	186	172	133	110	112	102

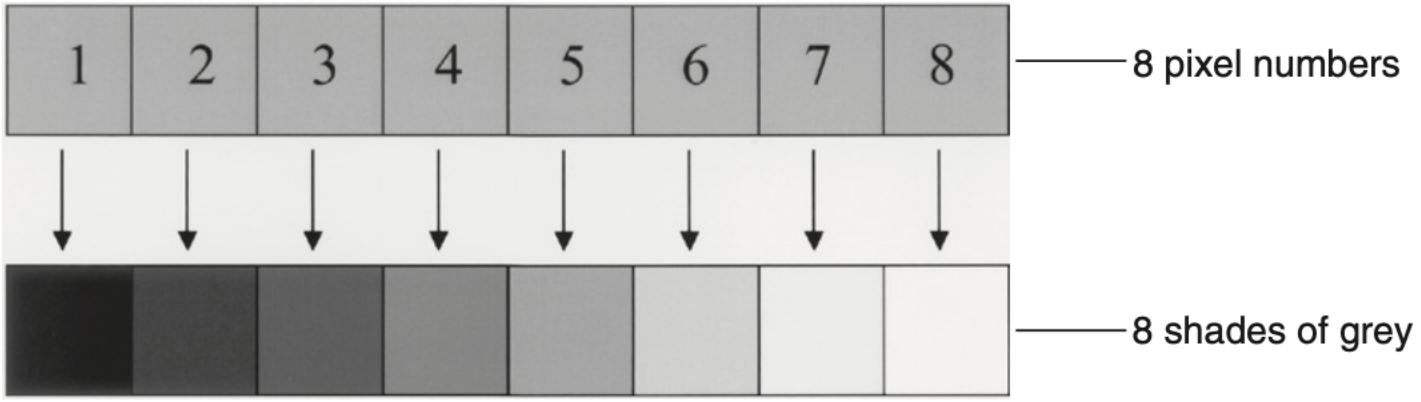
FIG. 4.1 A digital image is made up of a large number of discrete picture elements (pixels). The pixels are so small that the image appears smooth at normal magnification. The location of each pixel is uniquely identified by row and column coordinates within the image matrix. The value assigned to a pixel represents the intensity (gray level) of the image at that location.

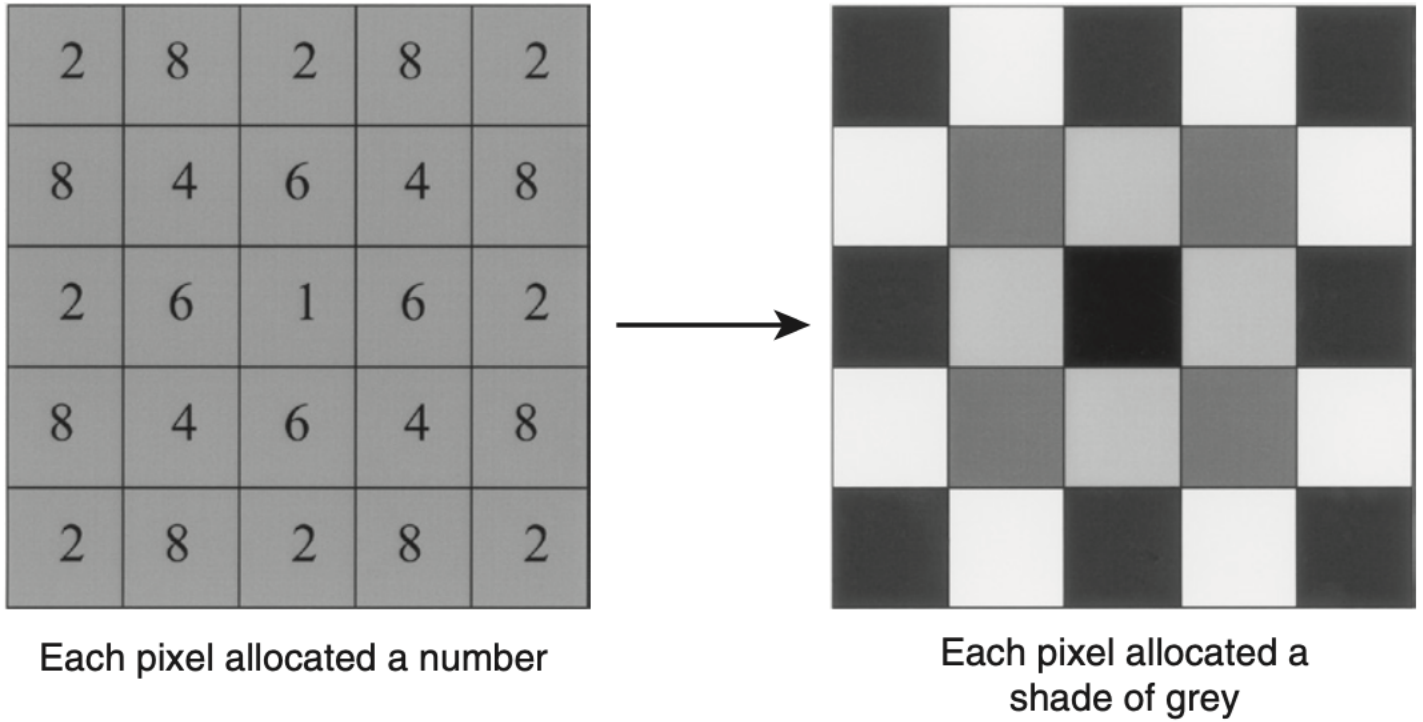


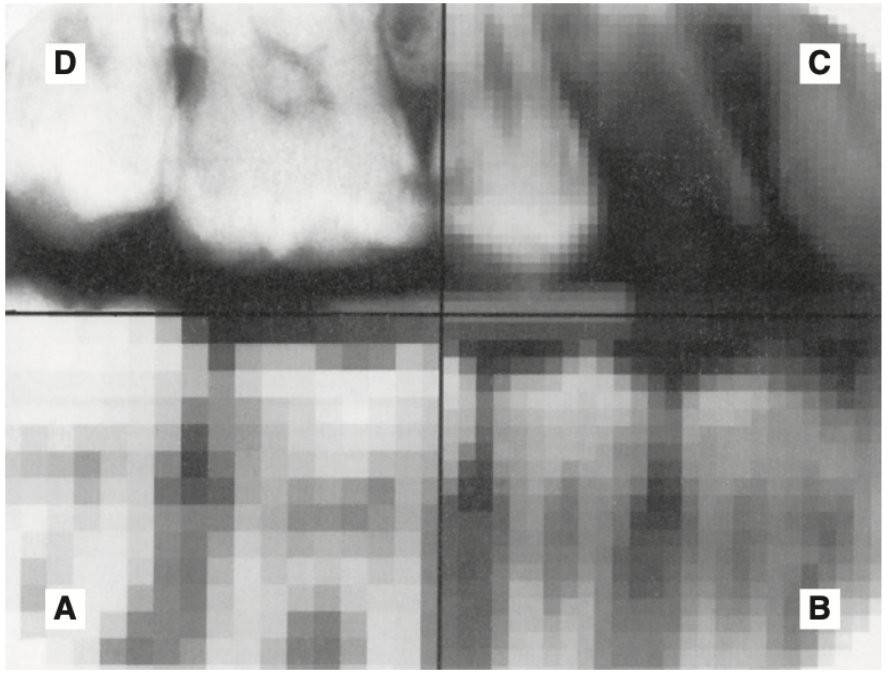
Analog-to-Digital Conversion (ADC)

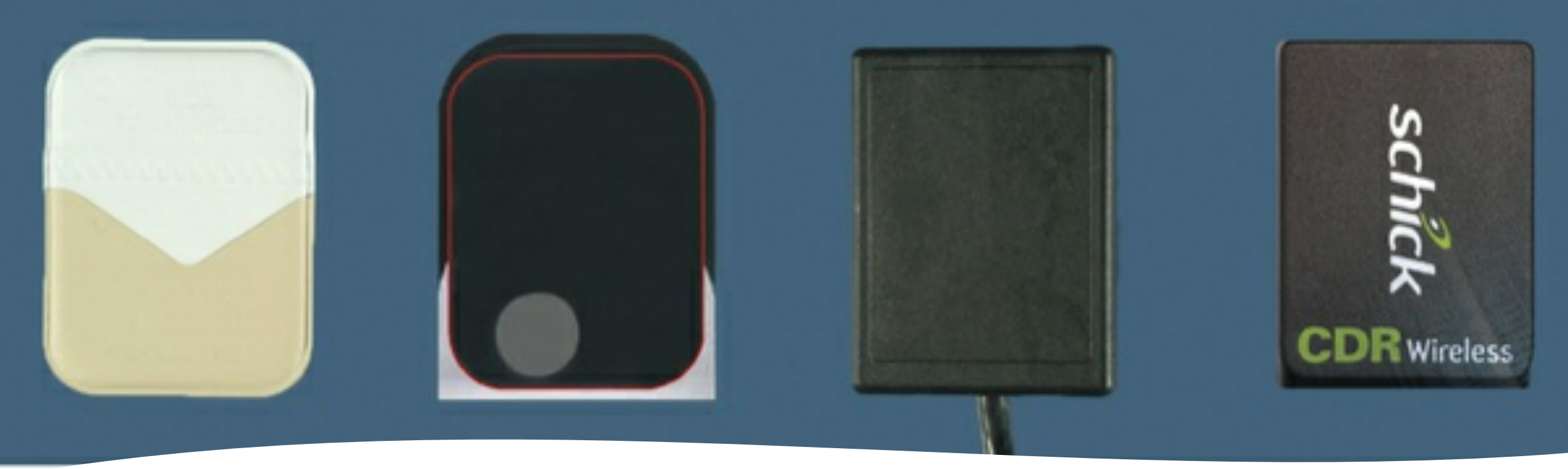
- Ie. From photons/voltages to digital Image
- Involves **TWO** steps
  - 1. Sampling
    - A range of voltages are grouped together
  - 2. Quantisation
    - Each sampled range is assigned a **grey value**
- Large sampling = ‘pixelated’ image ‘B’
- Narrow sampling = close to original signal ‘C’




1
2
3
4
5
6
7
8
8 pixel numbers
8 shades of grey


2 8 2 8 2
8 4 6 4 8
2 6 1 6 2
8 4 6 4 8
2 8 2 8 2
Each pixel allocated a number
Each pixel allocated a shade of grey


D
C
A
B

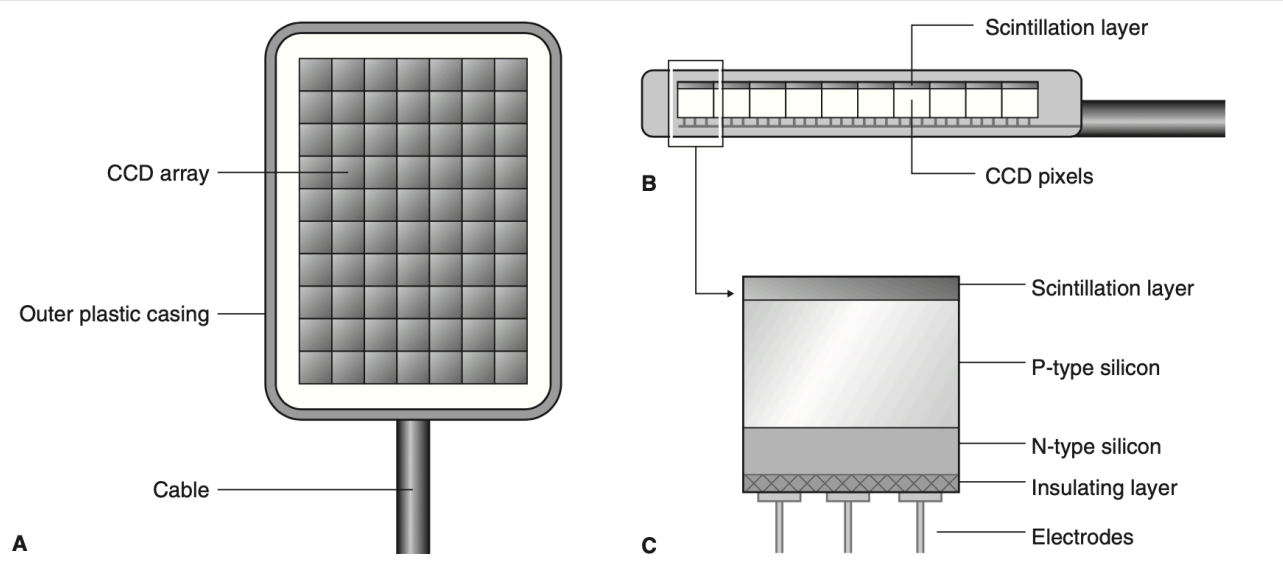


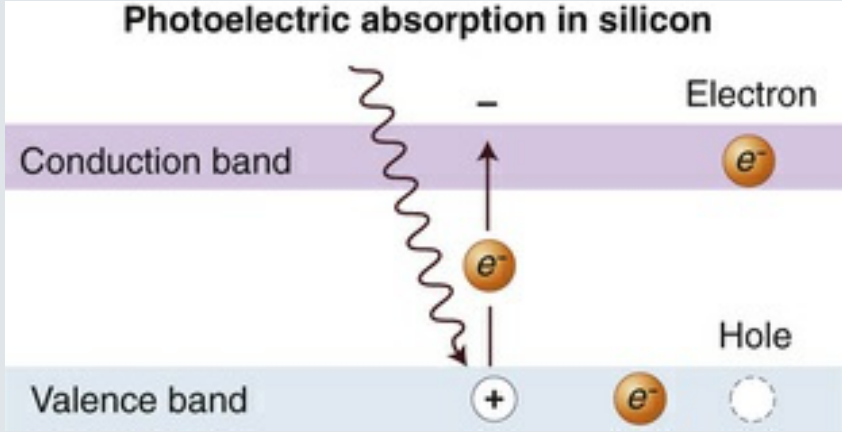
Digital Image Receptors

- **Two** types
  - Solid-state detectors / sensors
    - Charged-coupled device (CCD)
    - Complementary metal oxide semiconductors (CMOS)
    - *Flat panel detectors* ➔ *extra-oral use*
  - Photostimulable phosphor (PSP) plates

CCD

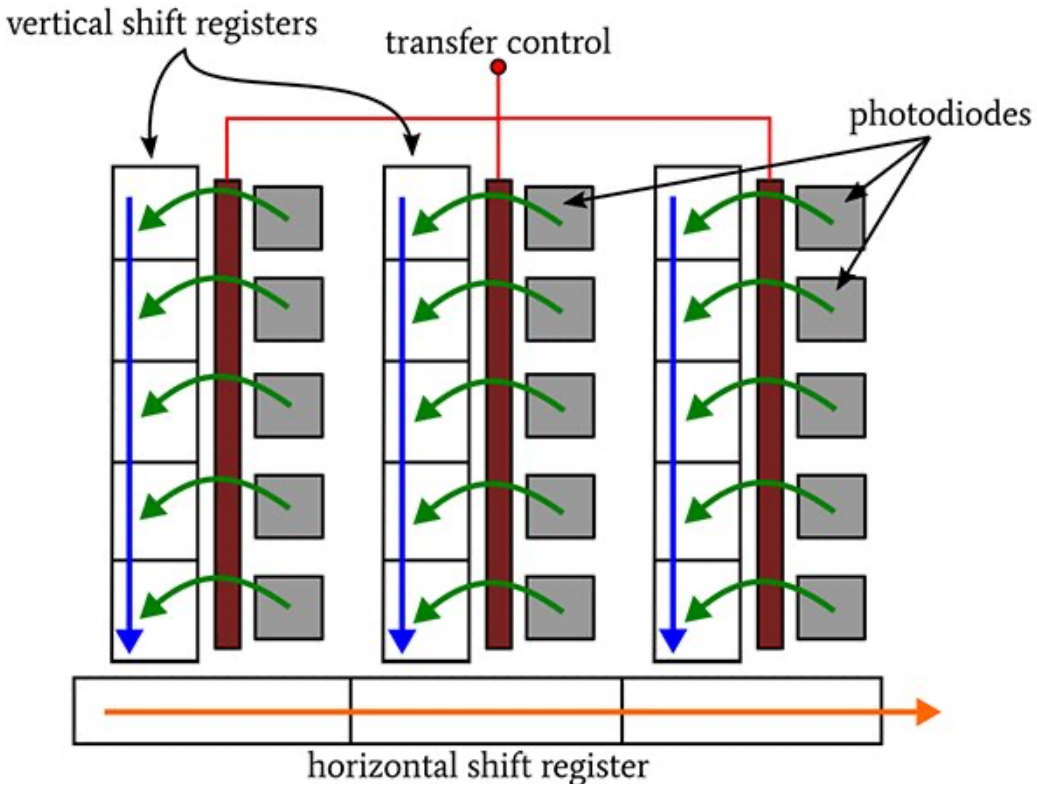
- charge-coupled device
- first digital image receptor to be adapted for intraoral imaging
- thin wafer of silicon pixels consisting of n-type silicon and p-type silicon covered with a scintillation layer
  - Light and silicon interaction creates **charge packet** for each pixel (latent image)





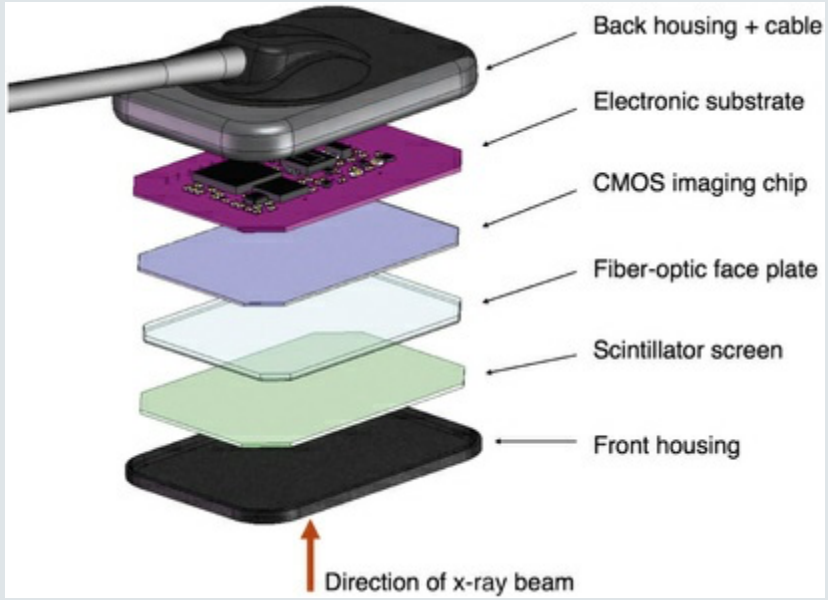
CCD Image Read-out

- “bucket brigade”
- As a charge reaches the end of its row, it is transferred to a readout amplifier and transmitted as a voltage to the ADC located within or connected to the computer



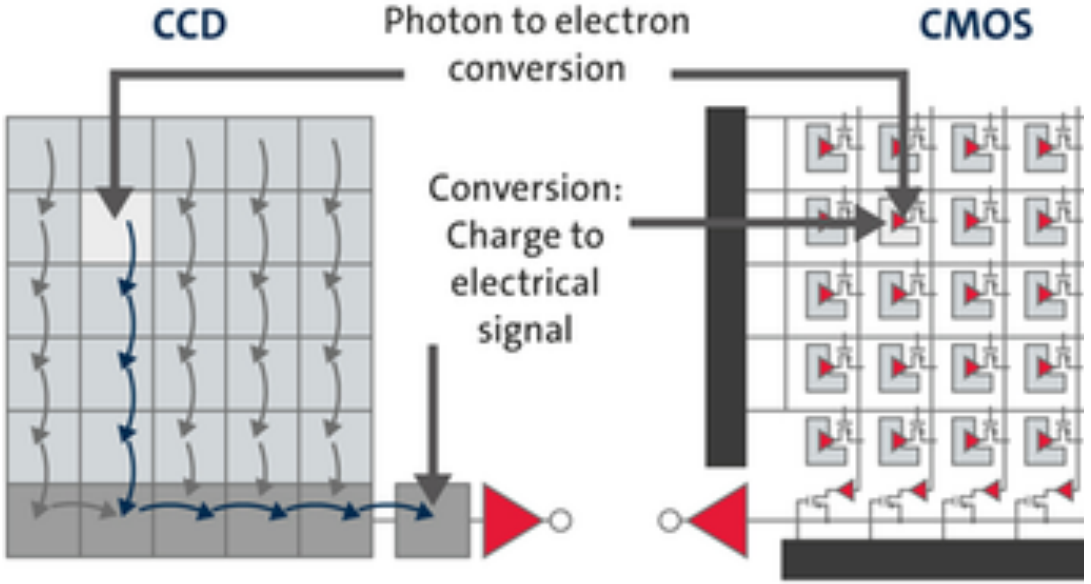
CMOS

- Complementary metal oxide semiconductor
- Basis for typical consumer-grade digital cameras
- Similar in construction to CCDs; consist of an array of pixels covered with a scintillation layer



CMOS Image Read-out

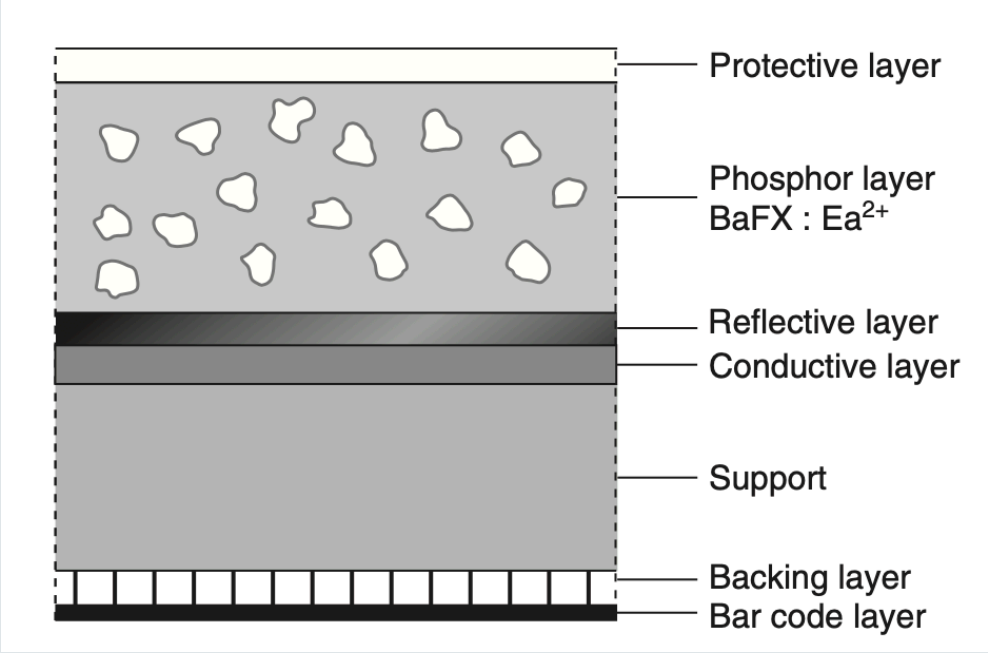
- Each CMOS pixel is isolated from its neighbour and directly connected to a transistor.
- The charge packet from each pixel is transferred to the transistor as a voltage enabling each individual pixel to be assessed separately.



Two different principles: CCD vs CMOS

PSP

- Photostimulable Phosphor
- Europium-doped barium fluorohalide
- Image processing is NOT instant
  - Absorb and store energy from x-rays ➔ latent image
  - Release this energy as light (phosphorescence) when stimulated by **another light of an appropriate wavelength (= scanner)**




A

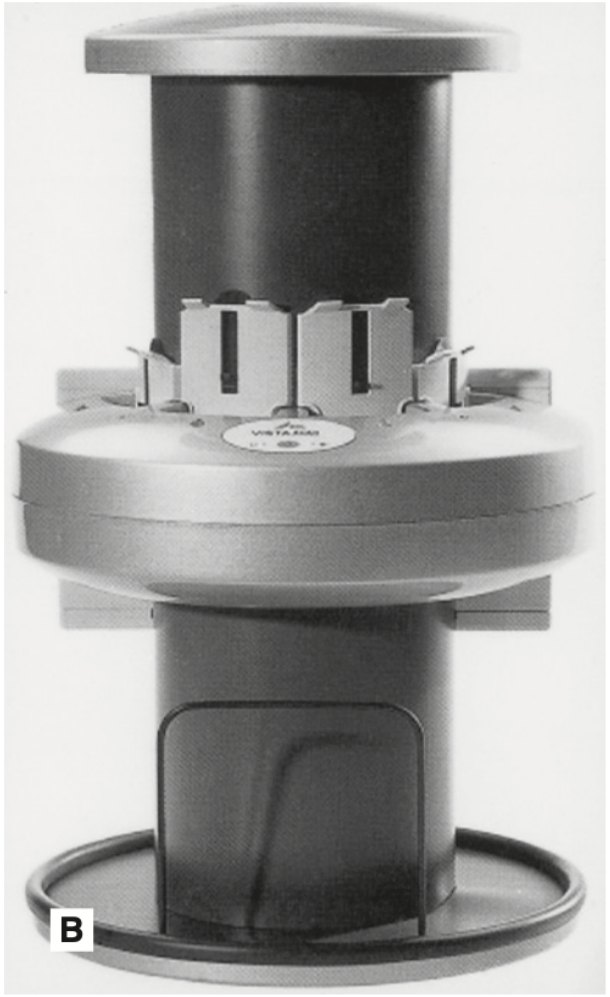

B

Image Resolution – Spatial Resolution

- Capacity for distinguishing fine detail in an image
- Measured and reported in units of line pairs per millimeter
- Eyes can detect 6 lp/mm.
  - Film > 20 lp/mm
  - SSD ~ 20 lp /mm
  - PSP ~ 10 lp/mm
- The smaller the size of the pixel, the higher the maximally attainable resolution

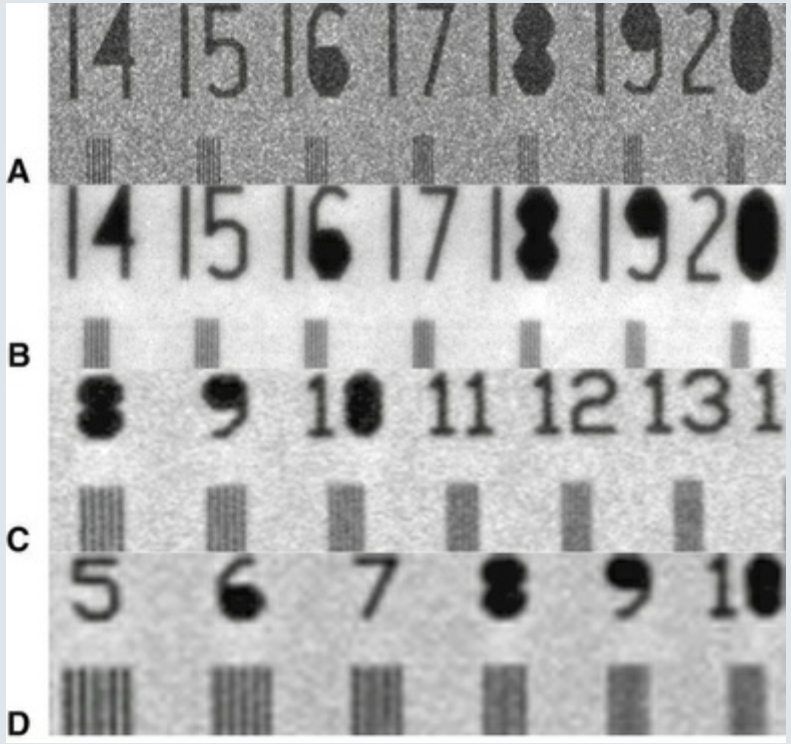


Image Resolution – Contrast Resolution

- Ability to distinguish different densities in the radiographic image
- Current digital detectors capture data at 8, 10, 12, or 16 bits.
- Conventional computer monitors are capable of displaying a grey scale of only 8 bits (2^8 = 256 shades of grey)
- The human eyes in darkroom / reporting room are capable of distinguishing 60 grey levels
  - Less than 30 grey levels in operatory dental clinics

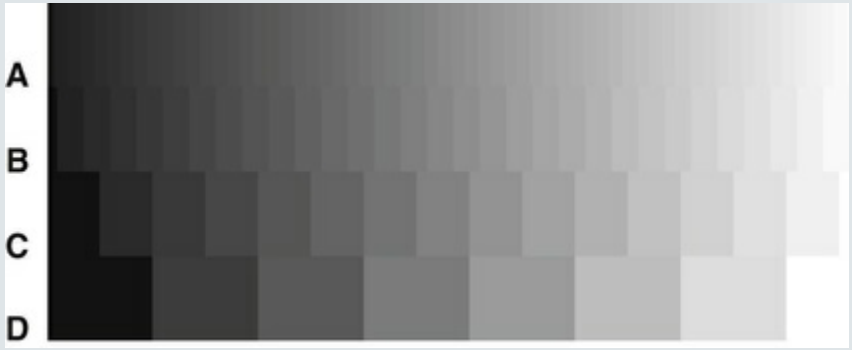


Image Manipulation / Adjustment

- Magnification
- Brightness
- Contrast
- Inversion
- Sharpening
- Smoothing

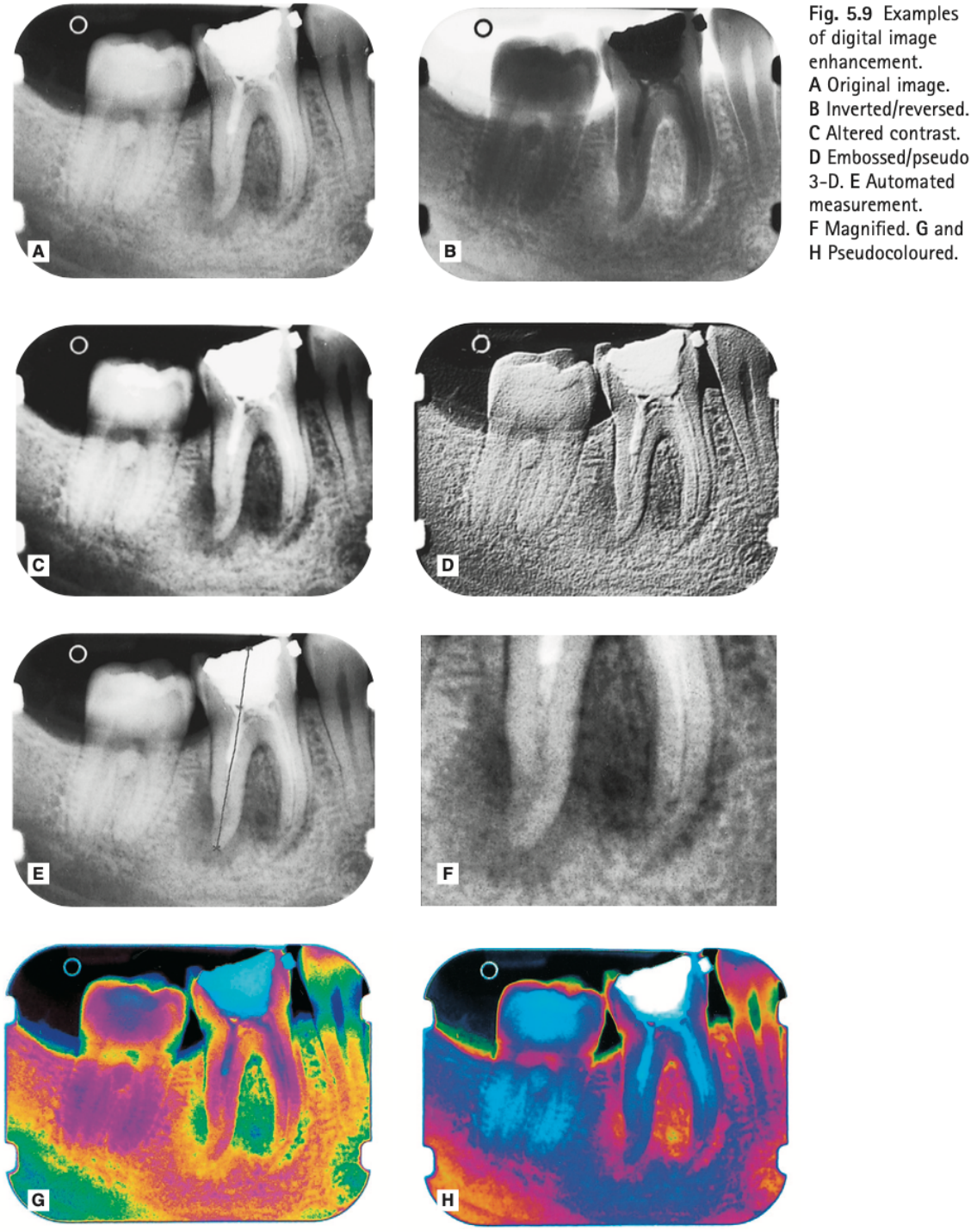
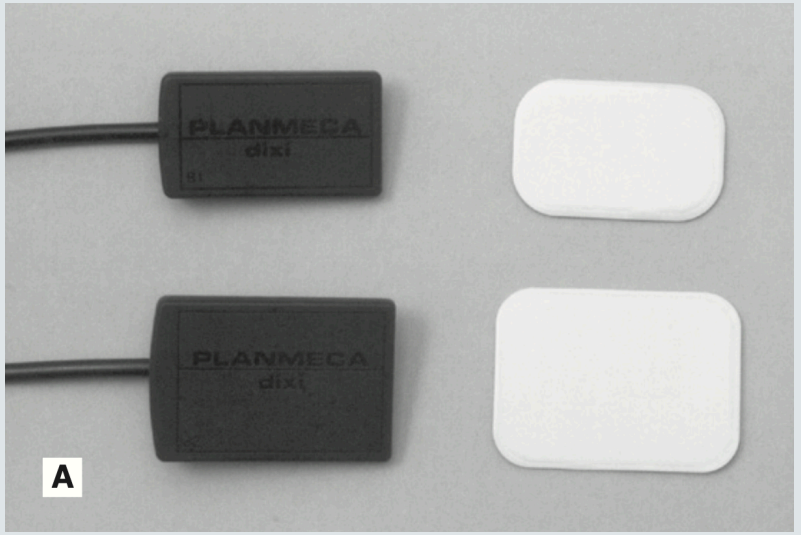


Fig. 5.9 Examples of digital image enhancement. **A** Original image. **B** Inverted/reversed. **C** Altered contrast. **D** Embossed/pseudo 3-D. **E** Automated measurement. **F** Magnified. **G** and **H** Pseudocoloured.

SSD vs PSP (clinical factors)



- Patient comfort
  - Intraoral SSDs are bulky (5-7mm) & often corded
  - PSPs are similar to films – flexible and thin
- Intra-oral holders
  - SSD holders are different
- Exposure
  - Computer & software must be ready before exposure
- Processing
  - SSDs are immediate
  - PSPs need a scanner
- Sterilisation

END.