Analogue Films & Common Film Faults

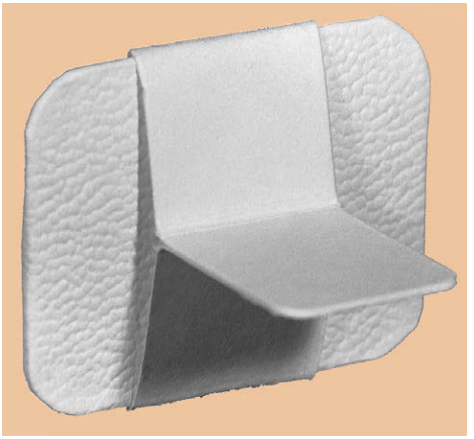
Dr Dayea Oh

OMF Radiologist

Review of Intra-oral Radiography

Intra-oral Radiography:

- 2D, diagnostic imaging using ionising radiation (= x-ray beam)
- Clinical workflow:
  - Film / receptor placed intra-orally → Expose (the film & the patient) with x-ray beam → film processing → diagnostic image production
- Images are of black (radiolucent), white (radiopaque) and grey ‘shadows’
- Three types:
  - Bitewing (BW), Periapical (PA) & Occlusal
- Digital or analogue



Left Posterior Bitewing (BW)

Learning Objectives

- Understand the **composition** of a general analogue film
- What is a **latent image**?
- How is a latent image **processed** to form a final image?
- What are the **factors that affect** the final **image quality**?
- Understand how to **assess faulty radiographs**

What you'll see on the outside…

- **Intra-oral film packet**
  - Plastic cover → *moisture-proof*
  - Orientation dot (dot to the mesial)
  - Inner paper wrap / black paper wrap
    → *light-proof*
  - Lead foil backing → *prevents residual radiation continuing on into patient's tissues*
  - ANALOGUE FILM

What you can't see inside…

- Double emulsion film →
- Emulsion = where image is recorded
  - Sensitive to x-rays, visible light & UV
  - Double layers (to reduce radiation dosage)
- Base = film support
  - Clear, transparent plastic
- Others:
  - Gelatin layer x2 (outer protective layer)
  - Adhesive layer x2 (between base & emulsion)

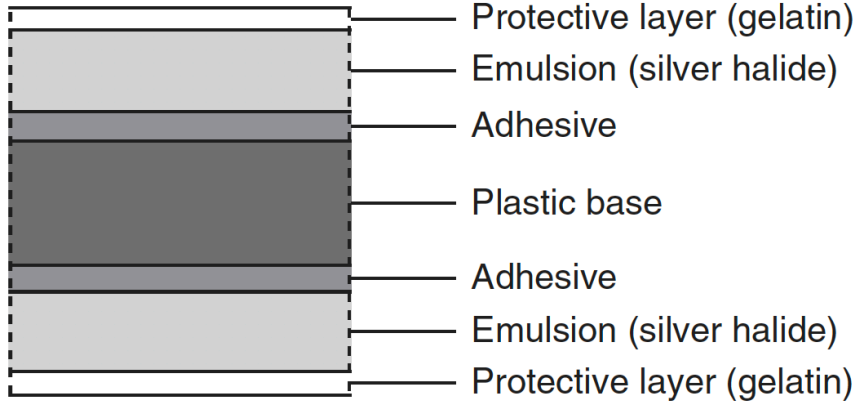
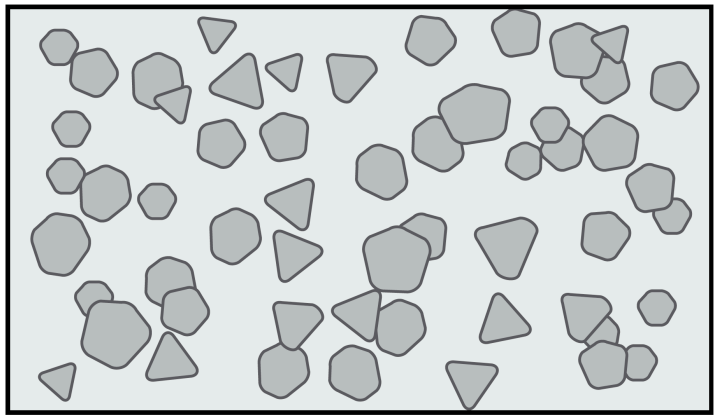


Fig. 4.3 Diagram showing the cross-sectional structure of double emulsion radiographic film.

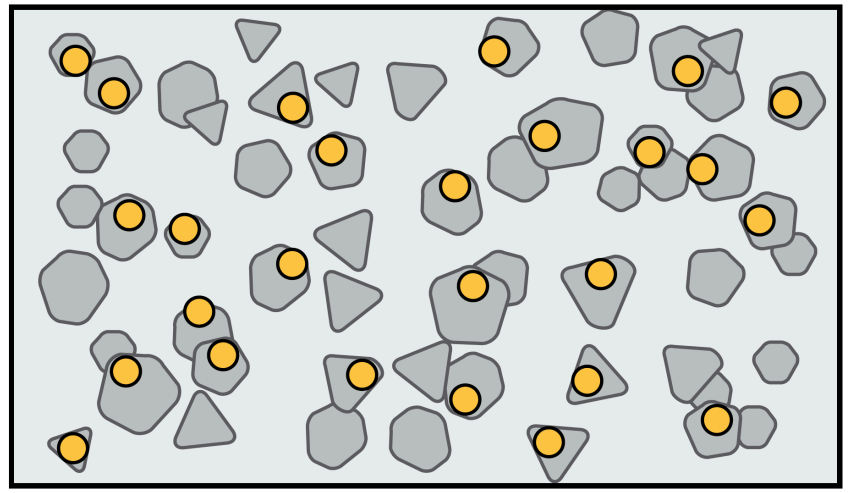
Emulsion

- Main components:
  - Silver halide crystals (or grains) → ***sensitive to x-ray photons!***
    - Mostly silver bromide (Ag-Br) crystals →
  - Vehicle / Gelatin matrix
    - Suspends silver halide crystals
    - Allows efficient chemical processing
  - Overcoat
    - To protect from damage eg. Scratch

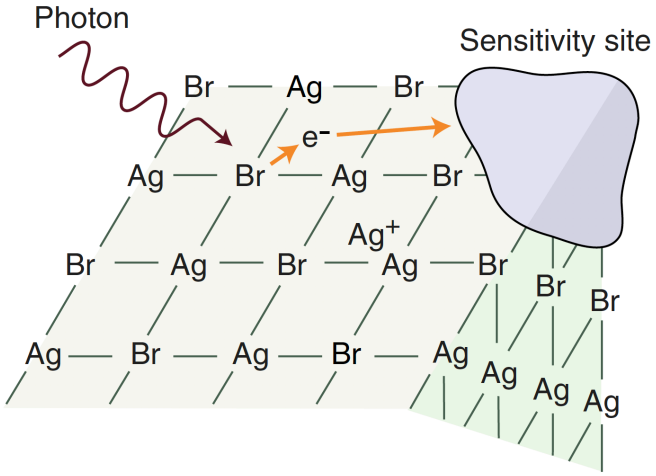


Latent Image Formation

- = exposed film →
- CHEMICAL change in film emulsion after x-ray exposure
  - Silver bromide (Ag-Br) crystals in the emulsion layer have:
    - Free silver ions (positively charged) and;
    - Sulfur compounds aka ‘sensitivity site’ (SS)
  - Irradiated silver bromide release electrons and bind to ‘SS’
    - SS become negatively charged
  - Free silver ions are attracted to –vely charged SS to form neutral silver atom



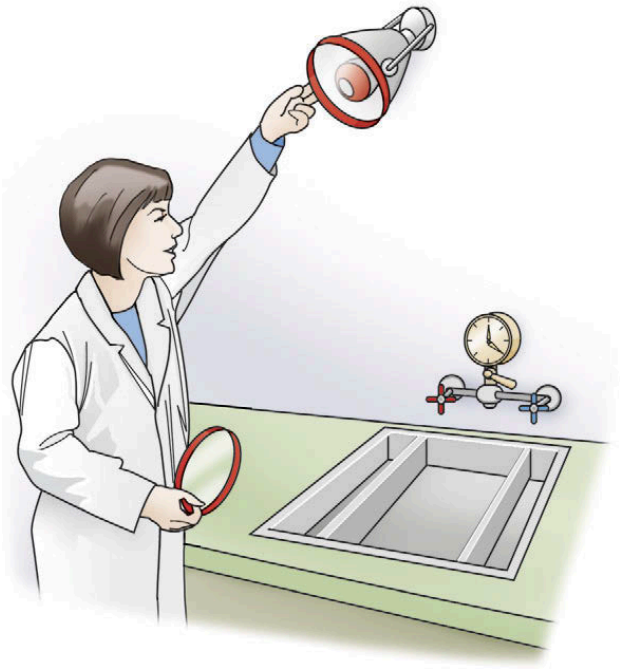
** Remember – only IRRADIATED (EXPOSED) Ag-Br crystals form latent image*



Latent Image to Final (Visible) Image

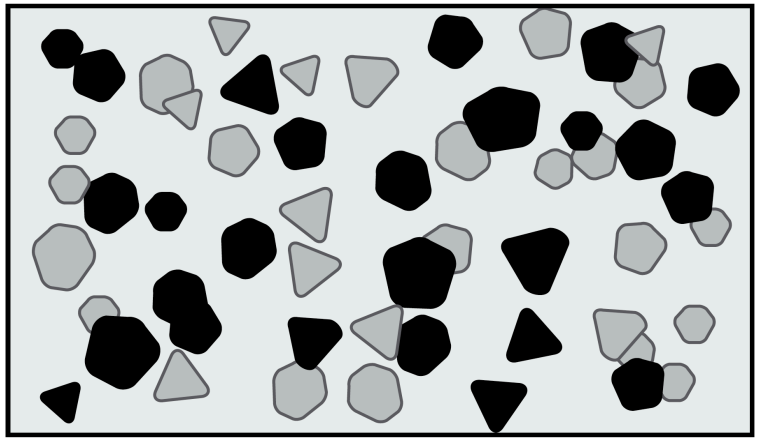
- Processing tank (stainless steel)
- CHEMICAL PROCESSING (4 steps)
  1. Developing solution
  2. Water
  3. Fixing solution
  4. Water

  & Dry & Mount
- Other requirements
  - Timer
  - Dry zone / area
  - Lightproof → ‘safelight’ Red GXB-2 filter (7.5-15W bulb)
  - Humidity → 50-70% relative humidity
  - Temperature → 20-25°C (room temp)



Chemical Processing – 1. Developing

- Target: latent image / exposed silver halide crystals
- Chemicals used:
  - **Phenidone** – converts latent image to metallic silver grains via oxidation
  - **Hydroquinone** – reduces oxidated phenidone to help continuing its action
  - **Sodium sulphite (antioxidant preservative)**
  - **Potassium carbonate (activator)**
    - Maintains alkaline environment (developers need pH ~10)
    - Swells gelatin layer to let developing agents to diffuse more readily
  - **Benzotriazole (restrainer)**
    - Restrains developing unexposed Ag-Br crystals → reduces image fogging
  - Glutaraldehyde
  - Fungicide
  - Water



- Duration: 3-6 minutes (depending on the temperature)

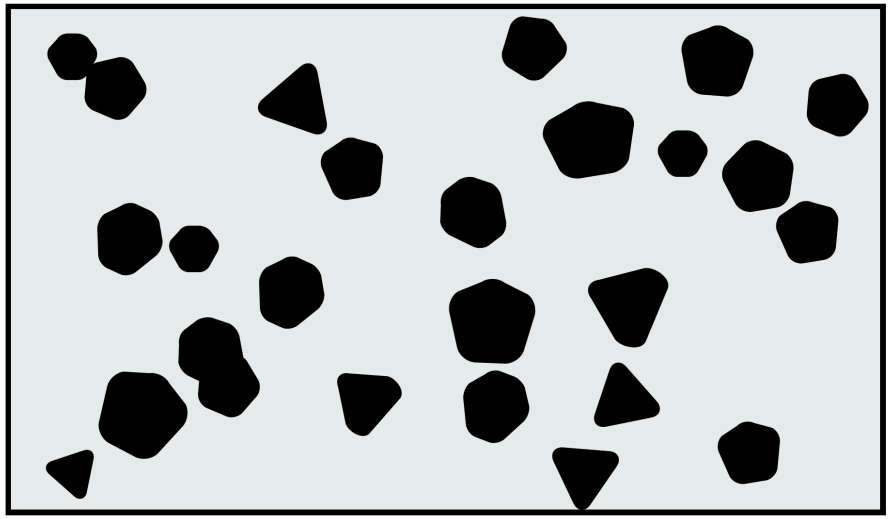
Chemical Processing – 2. Rinsing

- Rinse the film in water for with gentle agitation
- To:
  - Prevent over-developing
    - Over-developed images = dark final image (film fog)
  - Buffer to neutral pH

- Duration: 20-30 seconds

Chemical Processing – 3. Fixing

- Target = unexposed silver halide crystals
- Chemicals used:
  - **Ammonium thiosulphate** – removes/dissolves unexposed silver halide crystals
  - Sodium sulphate (preservative)
  - Aluminium chloride (hardener)
    - Reduces swelling of the gelatin from subsequent handling
  - Acetic acid (acidifier)
    - Maintains acidic environment (pH 4-4.5) for the fixer
    - Inactivates residual developing solution, if any
- Duration: 8-10 minutes

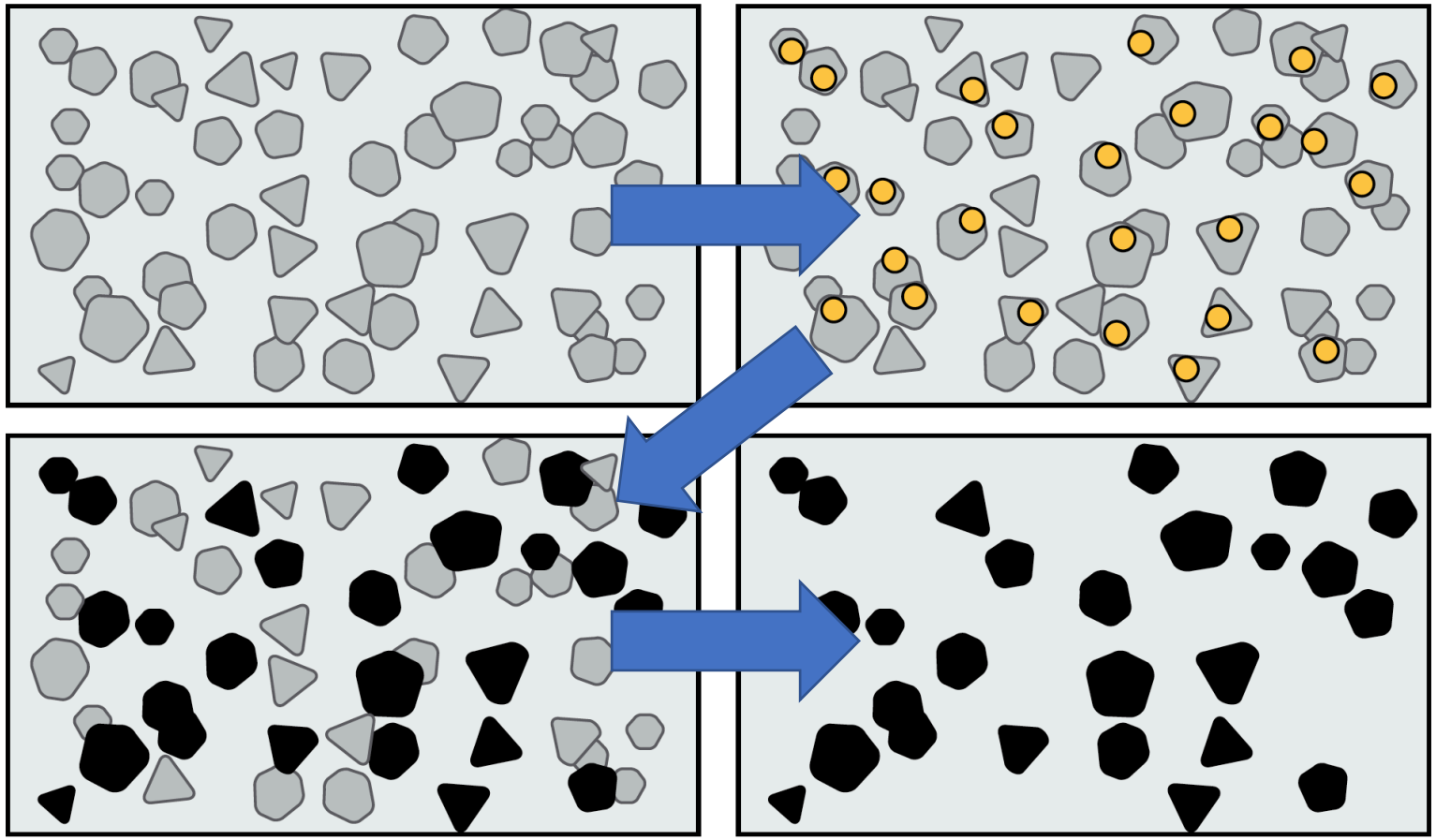


Chemical Processing – 4. Final Rinsing

- Rinse in water (in bath + under running water)
- To:
  - Prevent over-fixing
    - Over-fixing causes light image
  - Remove all the silver thiosulfate complexes (they cause fixer stains = obvious radiopaque areas on the final image)

Unexposed film & Ag-Br

Only exposed Ag-Br form latent image



Latent image become real image (image at this stage has fogging due to presence of remaining unexposed Ag-Br)

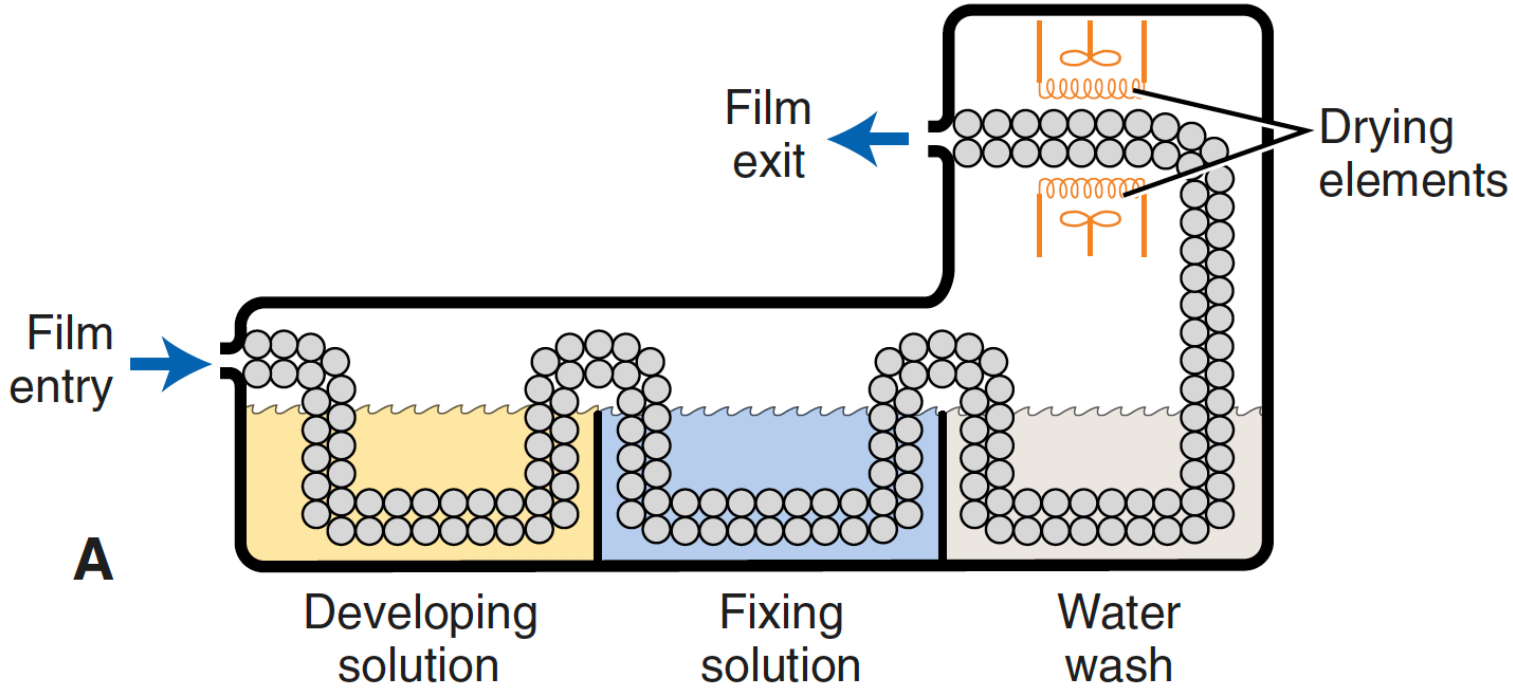
After fixing (final image)

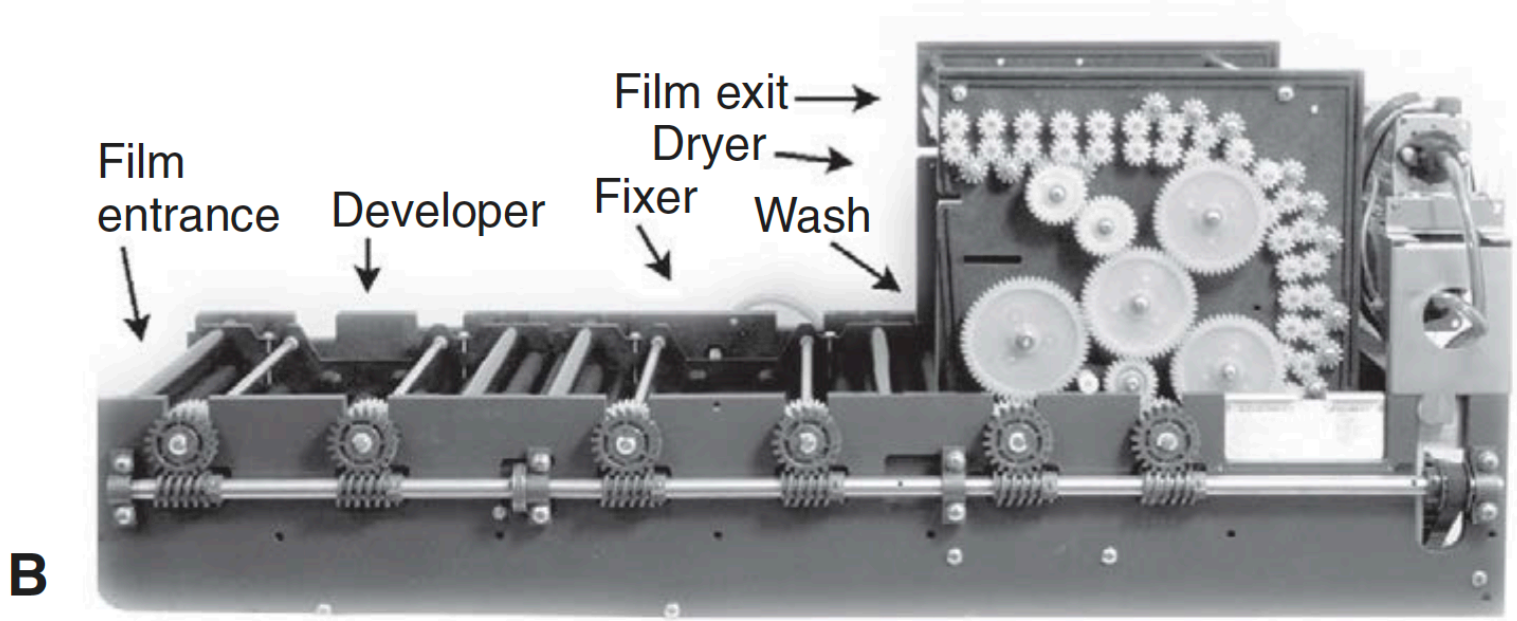
Darkroom Daily Start-up Protocol

- Clean & dry benches
- Check safelight & check for any light leaks
- Check chemical solutions (developers & fixers)
  - Check the volume & temperature
  - Stir to equalise the temperature throughout the tanks
  - Step-wedge test (mainly to test developer)
    - Compare daily ‘test film’ with initial ‘reference film’
      - Reference film = processed film when developer & fixer were newly replenished / replaced
    - When an optical difference is noted, all chemicals need replacement
  - Weekly clearing time test (fixer efficacy)
    - Measure time taken to remove all silver halide crystals (unexposed film)
      - Ideal = 8-10 min (at room temperature ~ 25°C)
      - Replace fixer if the clearing time doubles

Automatic Processing

- Manual processing can take up to >10 min.
- Compact ‘darkroom’ unit
  - No need for a separate dedicated darkroom
- Fast process
  - Passes successively through the developer → fixer → water → and drier (usually 5 min)
  - High concentration of hydroquinone in developing solution
- Often, inadequately rinsed → discolouration


Film exit
Drying elements
Film entry
A
Developing solution
Fixing solution
Water wash


Film exit
Dryer
Film entrance
Developer
Fixer
Wash
B

Analogue Film Viewing

- Mount ONLY DRY films
- Check orientation
- Mandatory information on mounted films:
  - Patient detail (name, gender, DOB)
  - Date of exposure
  - Type of film
  - Institution / address of practice
  - Exposure details (if possible)
- Light box

Film Storage

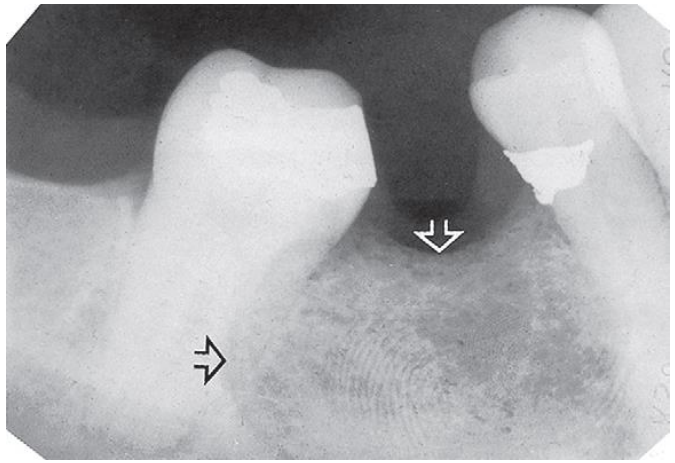
- Medicolegally, all films must be kept for 7 years*
  - If child, for 7 years after turning 18 years old
- Stored in a cool, dry place

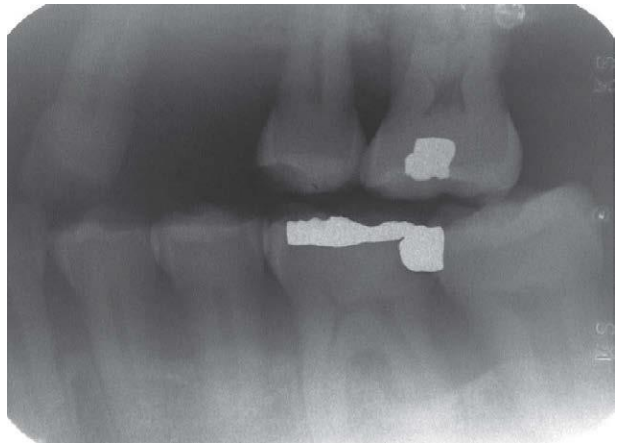
** Check AHPRA / ARPANSA / Radiation Health (in QLD) annually for any change*

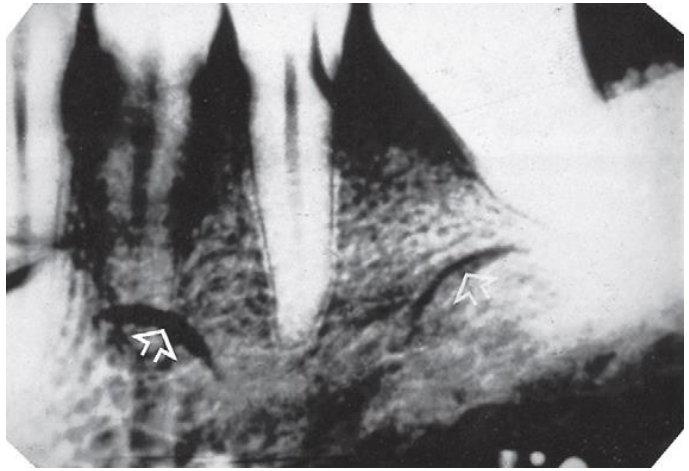
Common Film Faults

Processing Errors - I

- Light exposure in darkroom
  - Dark image = light leak into the darkroom
  - Film fogging (poor contrast, dark image) = prolonged exposure to safelight
- Poor handling
  - Fingerprints
  - Nails
  - Bent films
- Developing errors
  - Over-development → dark image
  - Under-development → light image
  - Contaminated film with developer before processing → black spots

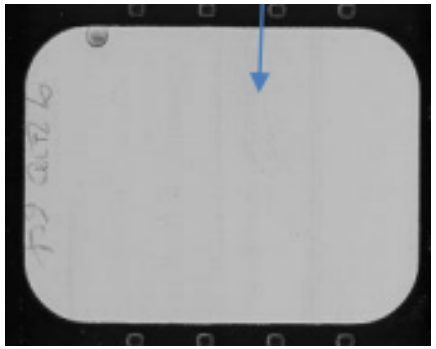


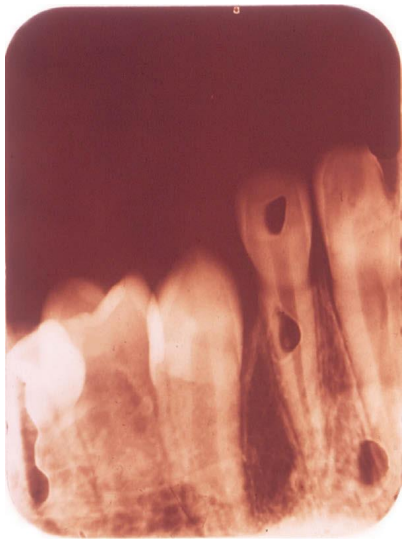




Processing Errors - II

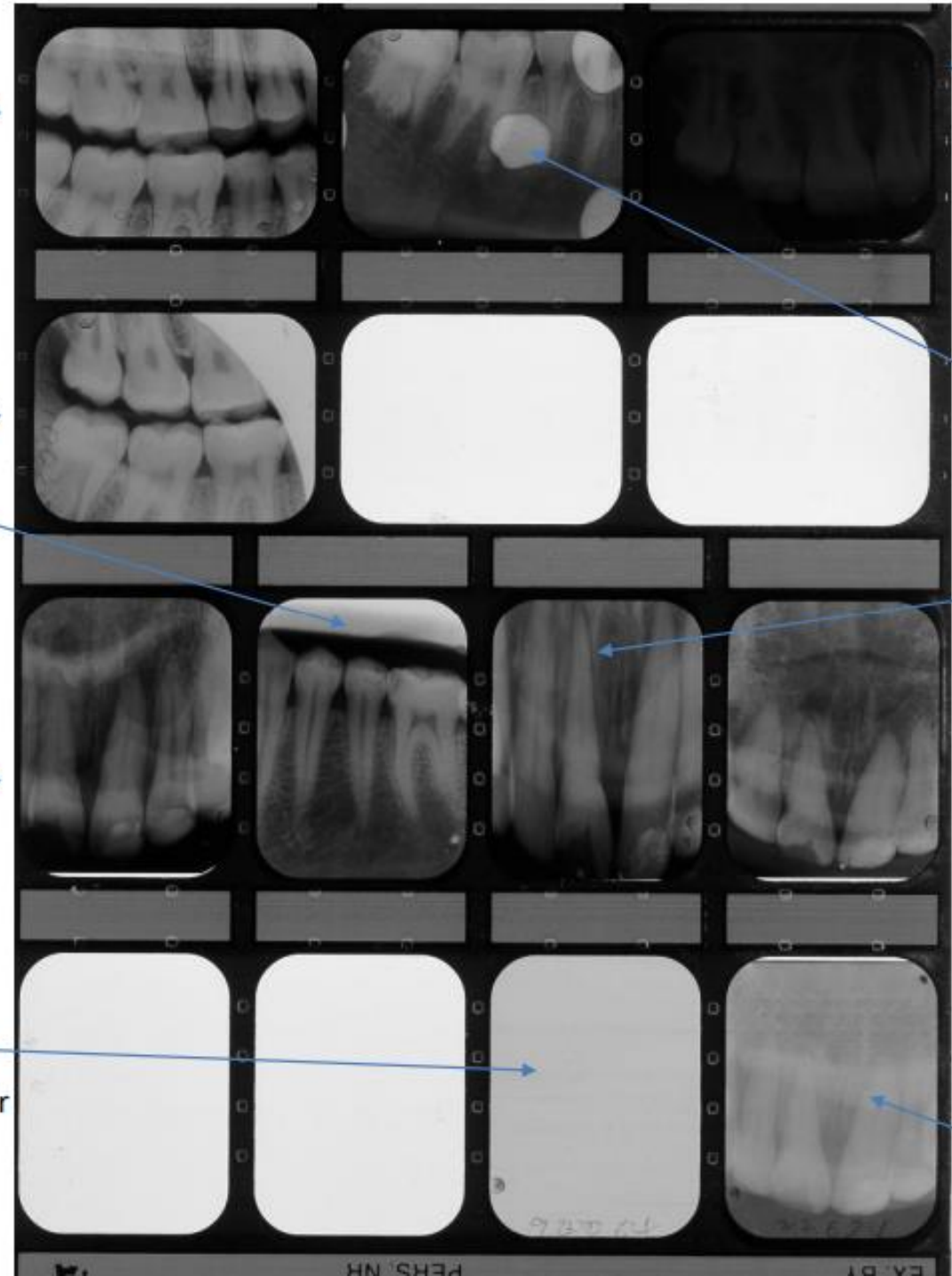
- Fixing errors
  - Over-fixing → light image (or clear)
  - Under-fixing → dark image
  - Contaminated film with fixer before processing → white / clear spots
  - Film in fixer before developer → clear image
- Rinsing errors
  - Inadequate rinsing → Brown image (usually from fixer staining)
  - Over-rinsing → emulsion peel ie. No image





Beam-related Errors

- Exposure setting errors
  - Underexposure → light image
    - Insufficient mA
    - Insufficient kVp
    - Insufficient time
    - Long film-source distance
    - Film reversed in mouth
  - Overexposure → dark image
    - Excessive mA
    - Excessive kVp
    - Excessive time
- Beam misalignment → Cone-cutting (partial image)


Partial immersion in developer
Over developed
Fixer splashed on film before processing
Cone cutting
Elongation
Not washing adequately post development or developer on film before processing
Forshortening
1. Not exposed
2. Left in wash over-night
3. Put into fixer before developer
Film positioned backwards

LIGHT RADIOGRAPHS (Fig. 5-34)

Processing Errors

Underdevelopment (temperature too low; time too short; thermometer inaccurate)
Depleted developer solution
Diluted or contaminated developer
Excessive fixation

Underexposure

Insufficient mA
Insufficient kVp
Insufficient time
Film-source distance too great
Film packet reversed in mouth (see Fig. 5-6)

DARK RADIOGRAPHS (Fig. 5-35)

Processing Errors

Overdevelopment (temperature too high; time too long)
Developer concentration too high
Inadequate time in fixer
Accidental exposure to light
Improper safelighting
Storage of films without shielding, at too high a temperature, or past expiration date

Overexposure

Excessive mA
Excessive kVp
Excessive time
Film-source distance too short

INSUFFICIENT CONTRAST (Fig. 5-36)

Underdevelopment
Underexposure
Excessive kVp
Excessive film fog

FILM FOG (Fig. 5-37)

Improper safelighting (improper filter; excessive bulb wattage; inadequate distance between safelight and work surface; prolonged exposure to safelight)
Light leaks (cracked safelight filter; light from doors, vents, or other sources)
Overdevelopment
Contaminated solutions
Deteriorated film (stored at high temperature; stored at high humidity; exposed to radiation; outdated)

DARK SPOTS OR LINES (Fig. 5-38)

Fingerprint contamination
Protective wrapping paper sticking to film surface
Film in contact with tank or another film during fixation
Film contaminated with developer before processing
Excessive bending of film
Static discharge to film before processing
Excessive roller pressure during automatic processing
Dirty rollers in automatic processing

LIGHT SPOTS (Fig. 5-39)

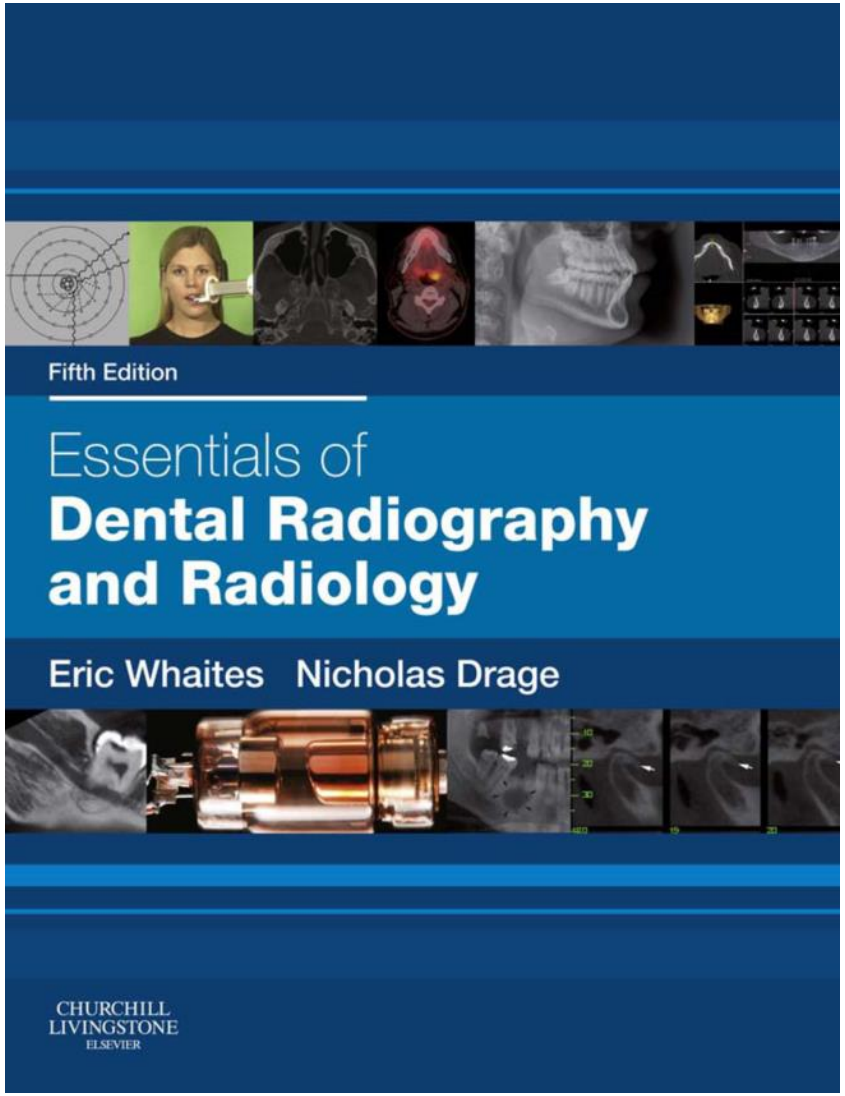
Film contaminated with fixer before processing
Film in contact with tank or another film during development
Excessive bending of film

YELLOW OR BROWN STAINS (see Fig. 5-16)

Depleted developer
Depleted fixer
Insufficient washing
Contaminated solutions

BLURRING (Fig. 5-40)

Movement of patient
Movement of x-ray tube head
Double exposure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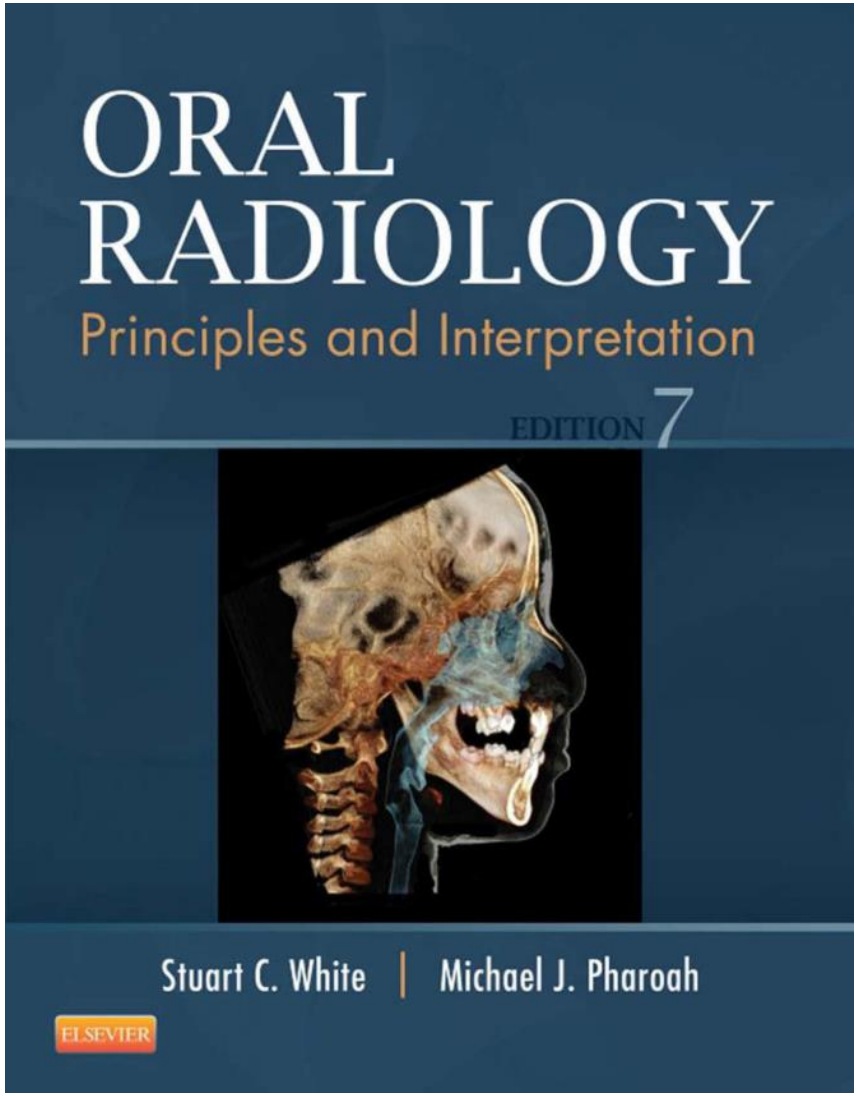
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