Sri Aurobindo College of Dentistry

Indore, Madhya Pradesh

INDIA

MODULE PLAN

- TOPIC: PROCESSING OF X-RAY FILM
- SUBJECT:OMDR
- TARGET GROUP: UNDERGRADUATE DENTISTRY
- MODE: POWERPOINT – WEBINAR
- PLATFORM: INSTITUTIONAL LMS
- PRESENTER: DR.PRIYA JOSHI

CONTENTS

INTRODUCTION

- ✓Processing is a collective title given to a series of operations carried out in the darkroom, which effect chemical changes in the exposed radiographic film, making the invisible latent image, contained in the sensitized film emulsion into a visible , permanent radiographic image.

- Freny R Karjodkar

- ✓ Film processing refers to sequence of events required to convert the invisible latent image contained in the sensitized film emulsion into the visible permanent radiographic image.

- Anil Ghom

PURPOSE

- Visible image formation
- Preservation of image

- ✓ A radiographic film (image receptor) is a recording medium used in dental radiography.

- ✓ When this film is exposed to the information carrying beam of photons exiting an object , the photosensitive silver halide crystals in the film emulsion interact with these photons and are chemically changed. These chemically altered crystals are said to constitute the latent (invisible) image of the film.

HISTORICAL BACKGROUND

- **Kells (1903)** is credited with being the first to change the processing tanks & time temperature processing .

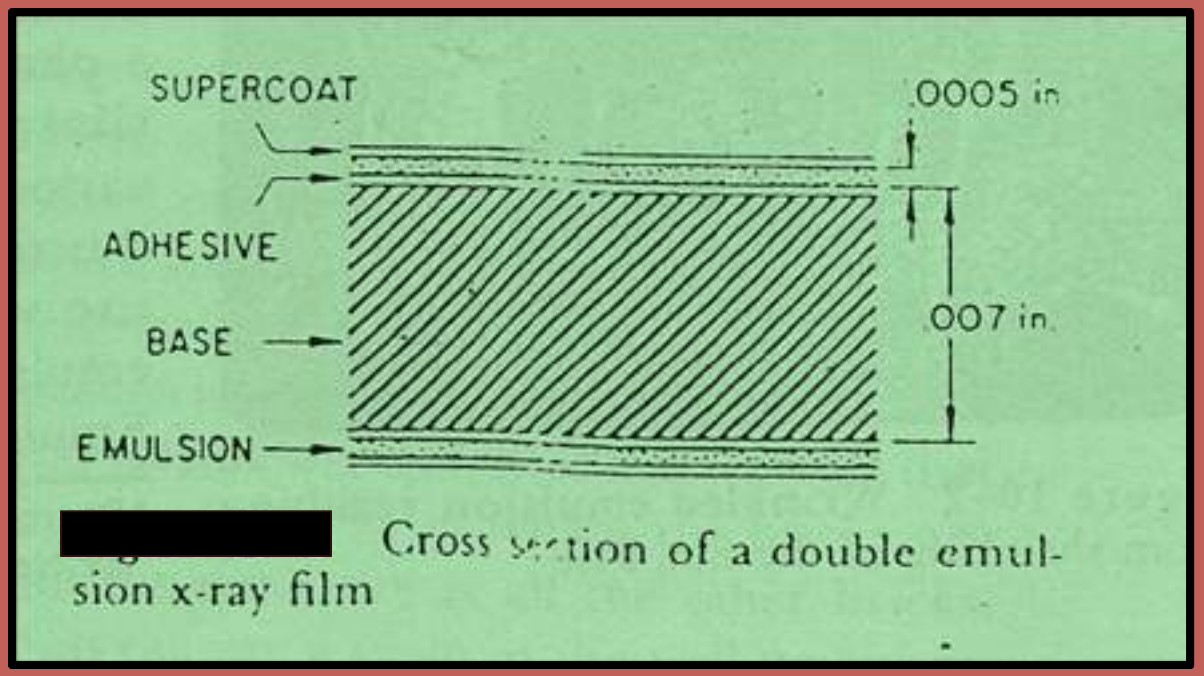
- **Cole (1910s)** pioneered advent of automatic processing.

- **Eastman Kodak Company (1918)** developed a darkroom with tank processing.

- **In 1920**, reliable film hangers became available.

FILM COMPOSITION

- X- ray film is a photographic film consisting of photographically active, or radiation sensitive, **emulsion** that is usually coated on both sides of a transparent sheet of plastic, called **base.**
- Firm attachment between the emulsion layer and the film base is achieved by use of a thin layer of **adhesive.**
- The delicate emulsion is protected from mechanical damage by layers known as the **super coating.**



[redacted] Cross section of a double emulsion x-ray film

FILM BASE:

- **The only function is to provide a support for fragile photographic emulsion.**

- **3 characteristics of base must be considered**
  - 1) It must not produce a visible pattern or absorb too much light when the radiograph is viewed.
  - 2) The flexibility , thickness , and strength of base must allow for ease of processing and produce a radiograph that feels right when handled.
  - 3) The base must have dimensional stability; that is the shape & size of the base must not change during the developing process or during the stored life of the film.

- The original x ray base consisted of “Glass plates” **(very fragile)**
- In 1914 , cellulose nitrate was adapted for use in x ray film **(quite inflammable)**
- In 1924 , cellulose triacetate base was developed**(safety film)**
- In 1960, polyester base was introduced**(improved dimensional stability, stronger than acetate)**

Thickness of triacetate base: 0.008 in.(8 mils)

Thickness of polyester base: 7mils

FILM EMULSION

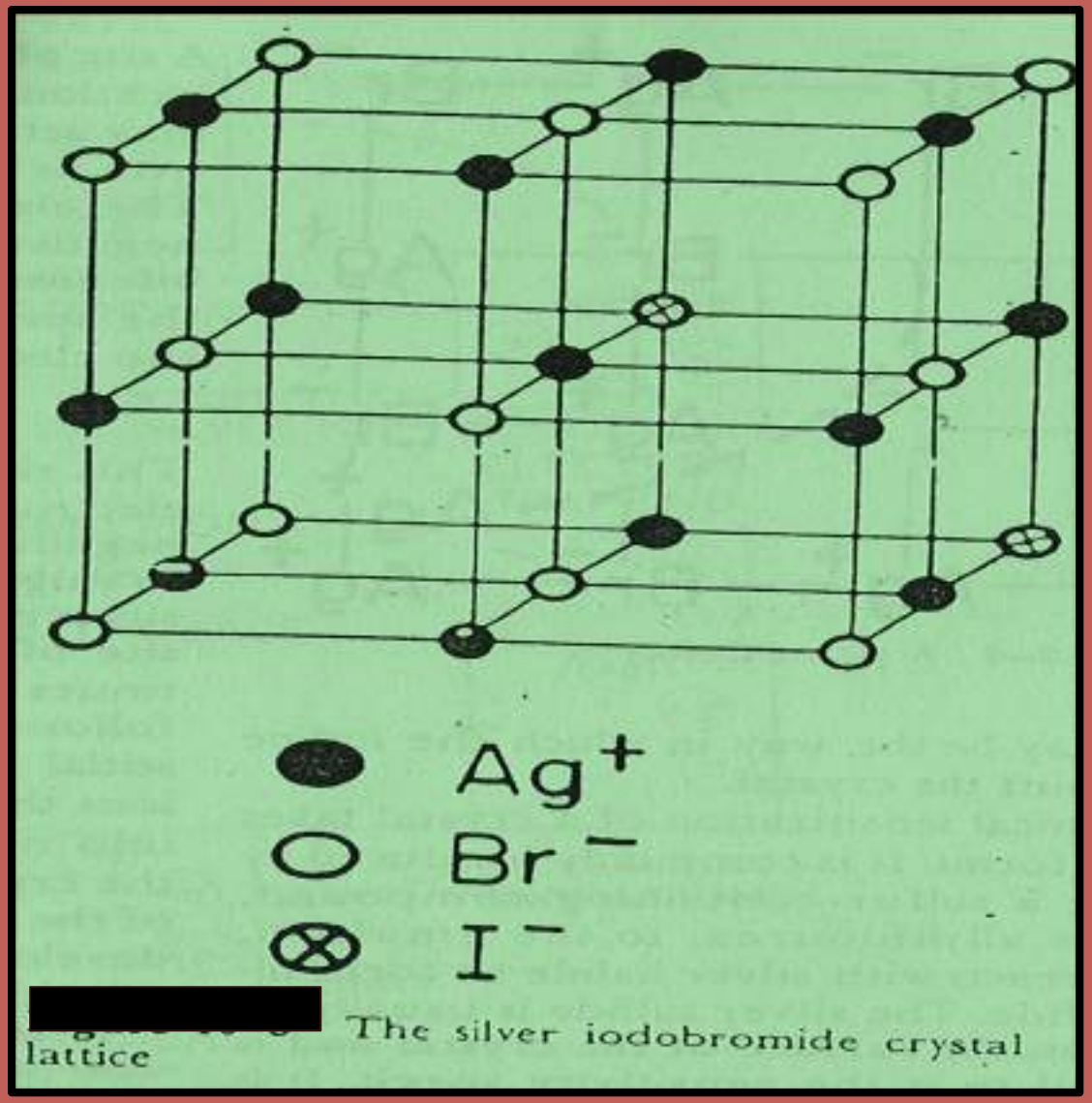
- 2 most important ingredients of photographic emulsion are gelatin & silver halide.
- Most x-ray film is made for use with intensifying screens, and has emulsion coated on both sides of the base.
- Emulsion thickness varies with film type, but is usually no thicker than 0.5 mil **(thicker the emulsion more difficult for light to penetrate to deeper layers).**

GELATIN:

- Made up of bone, mostly cattle bone.
- Salient Features
  - Keeps silver halide grains well dispersed and prevents the clumping of grains.
  - Processing solutions can penetrate gelatin rapidly without destroying its strength or performance
  - Available in large quantities & uniform quality.

SILVER HALIDE:

- Light sensitive material in the emulsion.
- Halide in medical X ray film is about 90-99% silver bromide and about 1-10% silver iodide(presence of Ag I produces an emulsion of much higher sensitivity than pure Ag Br emulsion)
- Silver halide in emulsion is in form of small **crystals** suspended in the gelatin.
- The crystal is formed from ions of silver, bromine & iodine arranged in a cubic lattice.



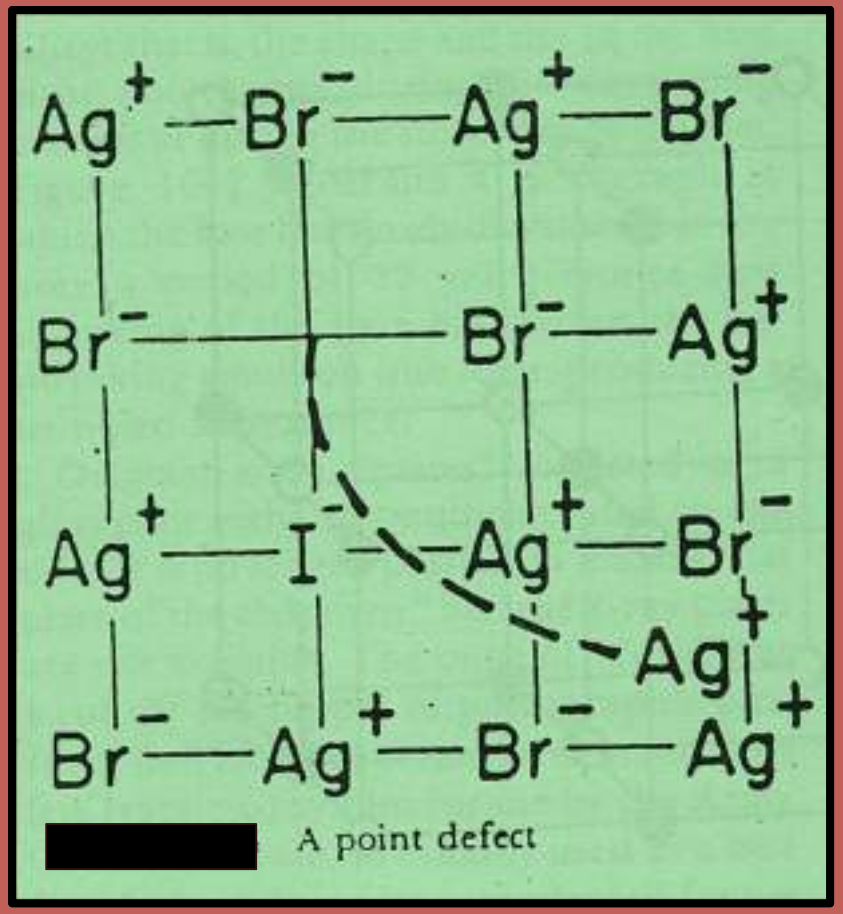
[redacted] The silver iodobromide crystal lattice

Crystal size might average 1.0-1.5 microns (1micron=0.001 mm) in diameter with about 6.3x10 9 grains per cubic cm of emulsion.

Each grain contains an average of 1,000,000 to 10,000,000 silver ions.

- The silver iodobromide grain is not a perfect crystal because a perfect crystal has almost no photographic sensitivity .

- Several types of crystal defects:
  - **Point defect** consists of a silver ion that has moved out of its normal position in the crystal lattice; these interstitial silver ions may move in the crystal.
  - **Dislocation defect** is a line imperfection in the crystal and may be thought of as a brick wall that contains one row in which the bricks are not the same size as all other bricks, thus causing a strain in the wall structure. This may be the way in which the iodine ion strains the crystal.


Ag+ Br− Ag+ Br−
Br− Br− Ag+
Ag+ I− Ag+ Br−
Ag+
Br− Ag+ Br− Ag+
A point defect

- Chemical sensitization of a crystal is commonly produced by adding sulfur containing compound, such as *allylthiourea* to the emulsion, which reacts with silver halide to form *silver sulfide.*

- **The silver sulfide is usually located on the surface of the crystal and is referred to as sensitivity speck.**

- **It is this sensitivity speck that traps electrons to begin formation of latent image centers.**

THE SILVER HALIDE CRYSTAL ARE IMPERFECT IN VARIOUS ASPECT:

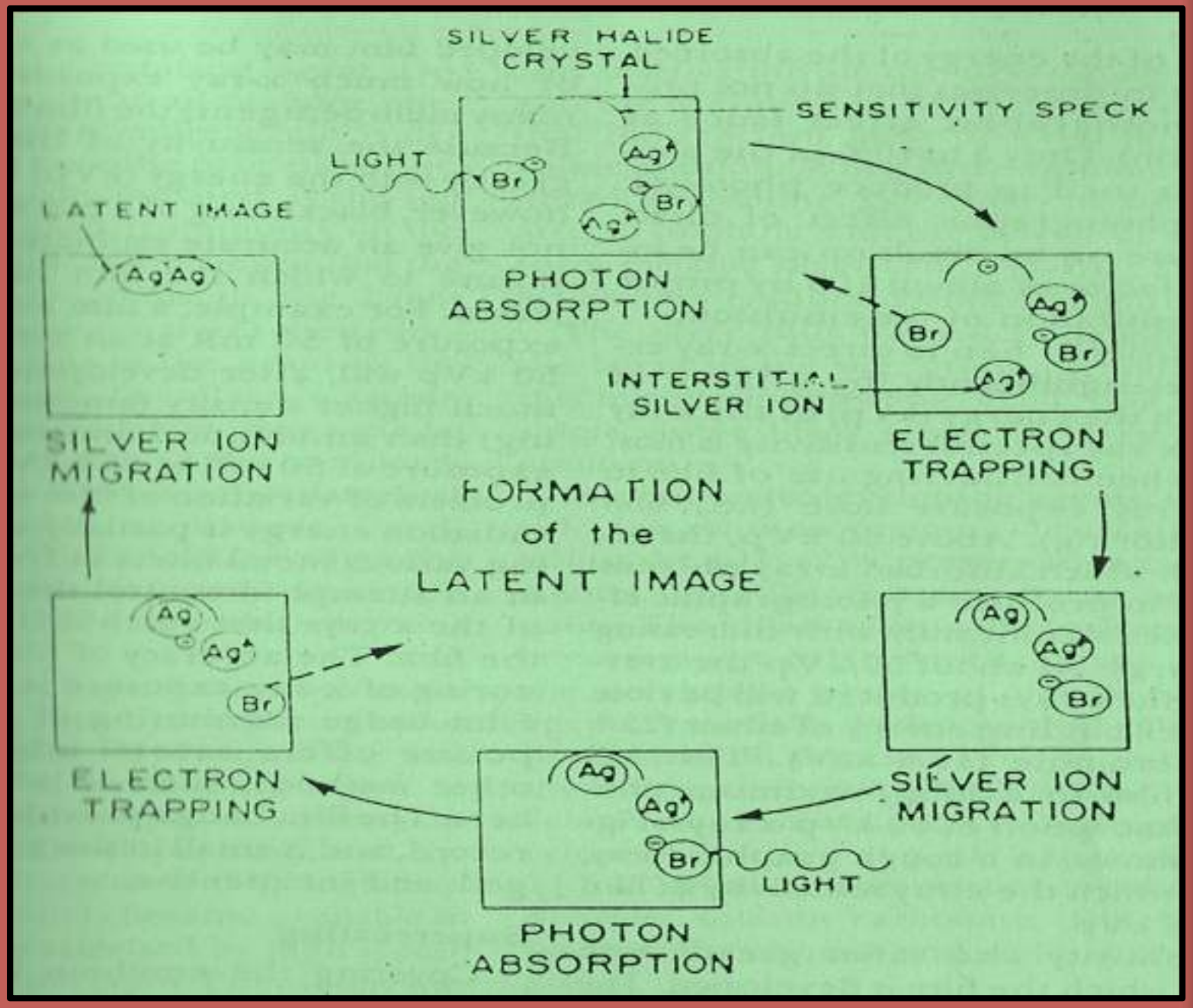
1. Interstitial silver ions: These are free in the spaces b/w the crystalline lattice.

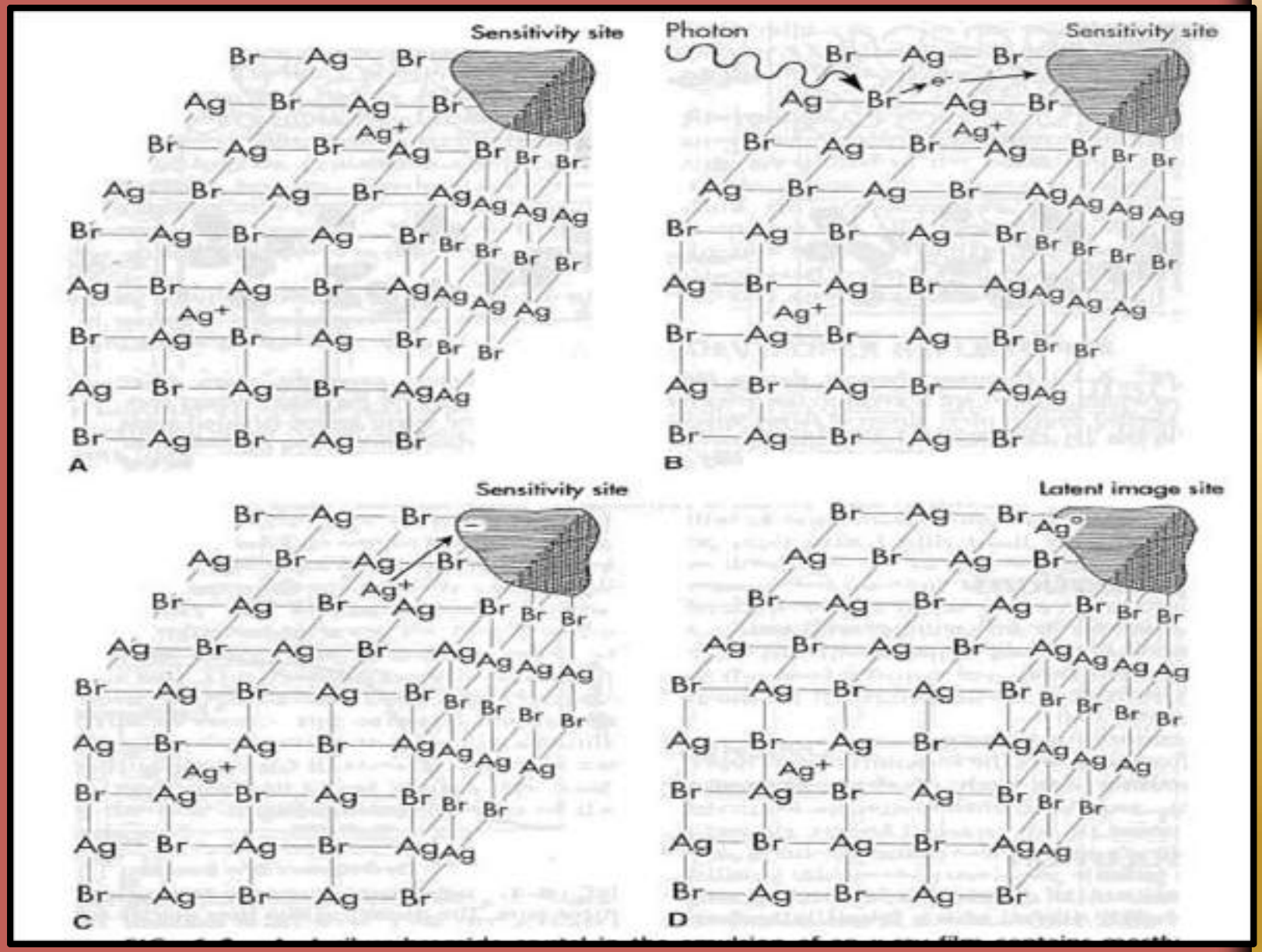
2. Physical distortion are present in the regular rectangular array of silver and bromide ion crystals due to the presence of iodine atom occupying some of the bromide site.

3. The silver halide crystal are chemically sensitized by the presence of sulphur compounds which cause physical irregularities in the crystal produced by iodide ions, and called *latent image sites*.

LATENT IMAGE FORMATION

- Metallic silver is black.
- It is silver that produces the dark areas seen on a developed radiograph.
- **GURNEY MOTT HYPOTHESIS**


SILVER HALIDE CRYSTAL
SENSITIVITY SPECK
LIGHT
Ag
Br
LATENT IMAGE
PHOTON ABSORPTION
INTERSTITIAL SILVER ION
SILVER ION MIGRATION
ELECTRON TRAPPING
FORMATION of the LATENT IMAGE
ELECTRON TRAPPING
SILVER ION MIGRATION
LIGHT
PHOTON ABSORPTION


Sensitivity site
A
Photon
Sensitivity site
B
Sensitivity site
C
Latent image site
D

- The clumps of silver atom can however be seen through electron microscopy. These are termed as latent image centers & are regarded as sites at which the developing process will cause visible amounts of metallic silver to be deposited.

- The difference between an emulsion grain that will react with the developing solution and thus become a visible silver deposit and a grain that will not be developed **is the presence of one or more latent image centers in the exposed grain.**
- At least **2 atoms** of silver must be present at a latent image center to make a grain developable(i.e. to become a visible deposit of silver)
- Under usual conditions the absorption of one quantum of light by a silver halide grain will produce **one atom of silver and one atom of bromine.**

PROCESSING SOLUTION

- The primary action of the processing solutions are to convert the crystals with the latent images into black metallic silver grains that can be visualized and to remove the unexposed silver bromide crystals.

Processing Solution

- **These may be obtained in the following form:**

  - Powder.
  - Ready to use liquid.
  - Liquid concentrate.

- **Special chemical solutions**

  Developer

  Fixer

- **Powder form:**
  - Must be mixed with distilled water.
  - Mixed solutions should be stored for later use in tightly stoppered brown bottles.

- **Liquid concentrates:**
  - *Convenient in most dental offices due to:*
    - Good strength
    - Little space requirement
    - Easy manipulation with distilled water

Developer solution:

Developer solution:

- **Reducing agent:** Elon~ hydroquinone
- **Preservative:** sodium sulphite.
- **Activator:** potassium carbonate / sodium carbonate.
- **Restrainer:** potassium bromide / benzotrizol.
- **Hardener:** Glutaraldehyde.
- **Fungicide:** To prevent the bacterial growth.
- **Buffer:** To maintain the pH(+7).

- Solvent: Water–:

– It is used as a solvent of the chemicals & as a medium in which they react with the silver bromide of the film emulsion.

Reducing agents:

1. Hydroquinone (paradihydroxy benzene).
2. Mentol or elon(mono methyl- para amine phenol sulphate.
3. Mentol phenidone(1- phenyl-3-pyrazolidone).

Hydroquinone (paradihydroxy benzene) :

- It is a benzene derivative and is concerned with the production of high contrast in the radiograph.
- Hydroquinone becomes relatively inactive in low temperature.

Mentol or Elon: -

- Mono methyl-para amine phenol sulphate is a by- product of analine dyes and helps develop the shadow areas or shades of gray on the film and bring out the details.
- It does not produce a high contrast.
- It is less sensitive to temperature changes.

Mentol phenidone (1-phenyl-3-pyrazolidone)

- This serves as the first electron donor that converts silver ions to metallic silver at the latent image site.
- The electron transfer generates the oxidized form of phenidone.
- Hydroquinone provides an electron to reduce the oxidized phenidone back to its original active state so that it can continue to reduce silver halide grains to metallic silver.
- Used in automatic processing.

Sodium sulphite: -(preservative)

- Sodium sulphite inhibits the tendency of the developing agent to combine with the oxygen dissolved in water or in the air.

- Oxidation of the developing agent forms colored substances which would stain the film and add to the film fog.

Potassium/Sodium Carbonate *(Activator):*

- It is added to the developing solution to proving and maintain the degree of alkalinity in which the developing agent can function.
- Excessive alkalinity will cause rapid reduction even of unexposed silver bromide crystals and produce fog.
- A low degree of alkalinity will slow down the process of development.
- Sodium hydroxide in conjunction with sodium carbonate may be used to give higher contrast.

Potassium bromide or benzotriazole *(Restrainer):*

- Potassium bromide slows down the reduction action of the developing agent, and has its greatest retarding effect on the development of unexposed crystals.
- It prevents excessive fogging of the film and increases the contrast.

Glutaraldehyde *(Hardener)*

- This is added especially in automatic processing, to prevent the emulsion from softening and sticking to the rollers.

Developer Replenisher

Developer Replenisher:

- Developer becomes inactivated by exposure to oxygen.

- The recommended amount to added daily is 8 ounce of fresh developer (replenisher) per gallon of developing solution, if approximately 30 IOPA's or 5 panoramic films developed per day.

Factors affecting developer solution:

- Temperature: Higher temp deteriotes the strength of the developer.
- Number of films: more films are developed daily, then developer depletes rapidly.
- Uncovered tank: Chances of solution getting oxidized.
- Mixing of fixer with developer: If fixer gets spilled in developer tank, developer gets deteriorated.

Test Of Developing SolutionStrenght:

- Radiograph of adequate strength is kept as *reference radiograph* and the images taken later are compared with these reference radiographs.
- Decrease in image contrast and density becomes evident as solution deteriorates.

Rinsing

Rinsing

- After development the film emulsion swells and become saturated with developer.
- At this point the films are rinsed in water for 15- 20 seconds with continuous gentle agitation before they are placed in the fixer.
- It also removes the alkali activator preventing neutralization of the acid fixer.

Fixing Solution

Fixing solution

- The primary function of the fixing solution is to dissolve and remove the undeveloped silver crystals from the emulsion.
- The 2nd function of fixing solution is to harden and shrink the film emulsion.
- As developer, fixer should be replenished daily at the rate of 8 ounces per gallon.

Fixing solution

- Fixing solution are: -

  Clearing agent – Ammonium/ Sodium thiosulphate

  Preservative - Sodium sulphite

  Acidifier - Acetic acid

  Hardener –Aluminum chloride/ Aluminum sulphite/
  Potassium alum.

  Solvent – Water

Ammonium/ Sodium thiosulphate (*Clearing agent*)

- Hypo is the one of the few substances which will remove silver bromide without adverse effect on the film.
- The chemical reacts with the undeveloped silver bromide and converts it into a soluble substance which can be subsequently washed out of the film.

Sodium sulphite *(Preservative)*

- It prevents the oxidation of the clearing agent, which is unstable in the acidic environment.

- Sodium sulphite also bind with any colored oxidized developer carried over into the fixing solution, and thus prevents any oxidized developer from staining the film.

Acetic acid *(Acidifier)*

- The acetic acid buffer system (pH 4 to 4.5) help to keep to the fixer pH constant.
- This acetic pH is require to promote good diffusion of the thiosulphate into the emulsion and of silver thiosulphate complex out of the emulsion.
- The acidic solution also neutralized any developing agent carried over, thereby blocking any further development of any unexposed crystals while the film is in the fixing tank.

Aluminum chloride/ Aluminum sulphite/ Potassium alum *(Hardener)*

- These substance form complexes with the gelatin during fixing and prevent further damage to the gelatin during subsequent handling.
- The hardeners also reduce the swelling of the emulsion during the final wash.
- This lessons mechanical damage to the emulsion and limits water absorption, thus shortening the drying time.

Water (Solvent)

- The fixing solvent should be made up in according with the manufacture's instructions and used at a temperature of about 68°F (20°c).

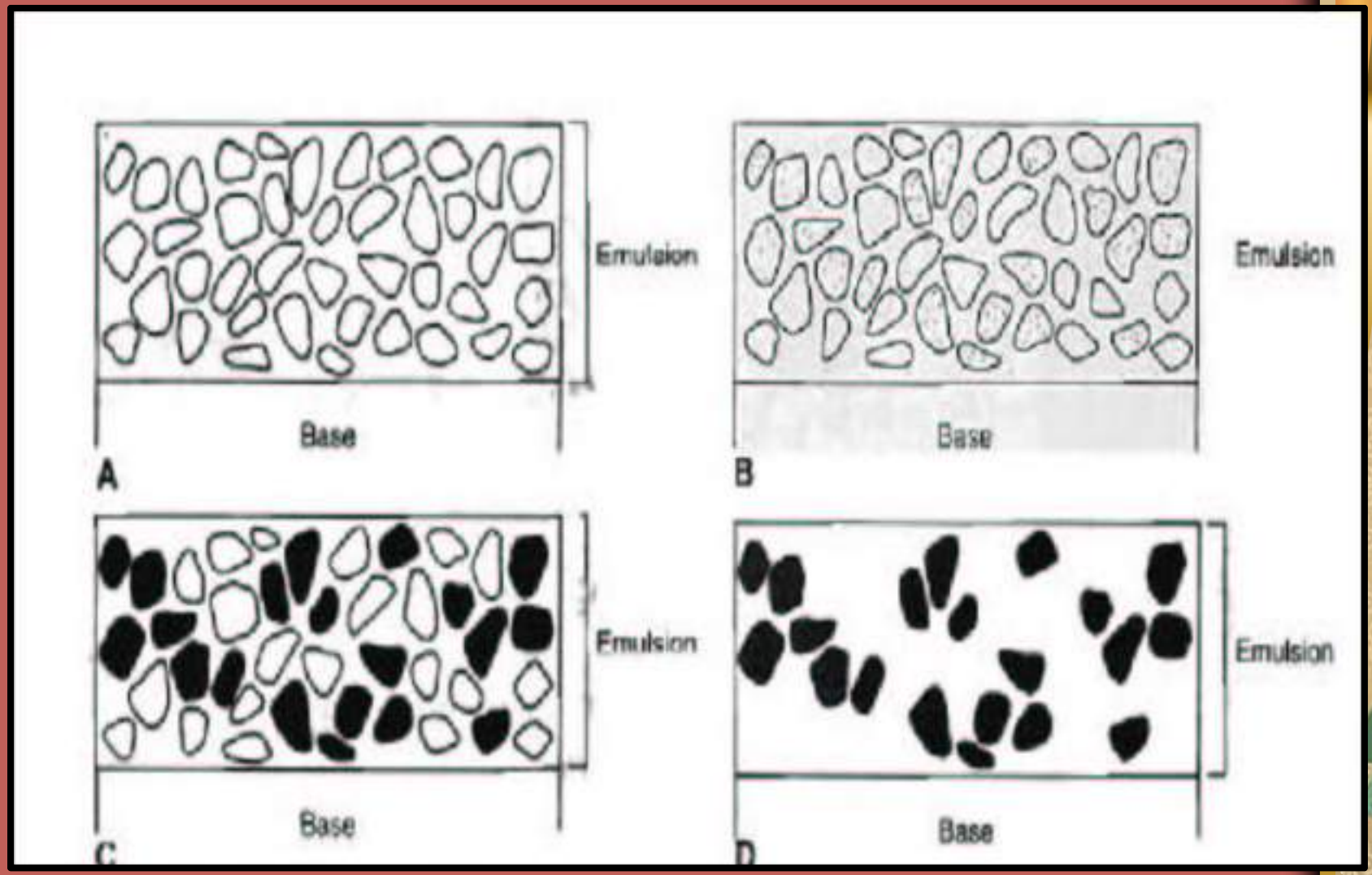
WASHING

Washing :

- After fixing, the processed film is washed in a sufficient flow of water for an adequate time to ensure removal of all thiosulphate ions and silver thiosulphate complexes.
- Washing efficiency declines rapidly when the water temperature falls bellow 60 °F.
- The film is washed for about 20 minutes in the water tank to remove the fixing solution from the emulsion.

When to change processing solution?

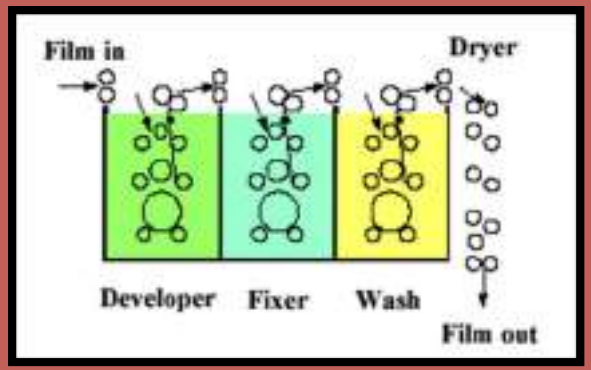
- When processing solution becomes exhausted and prolonged processing time is required to develop and fix the exposed film.
- Under normal circumstances , it should be changed every 2-3 weeks.
- A normal workload is 30 intraoral films per day.
- If panoramic films are processed it should be changed more frequently as it needs more chemical per unit area.



SCHEME OF EMULSION DURING FILM PROCESSING

***Film processing involved the following procedures:**

1. Immersion of exposed film in developer solution.
2. Rinsing in running water.
3. Immersion in fixing solution.
4. Film washing.
5. Drying and mounting for viewing.

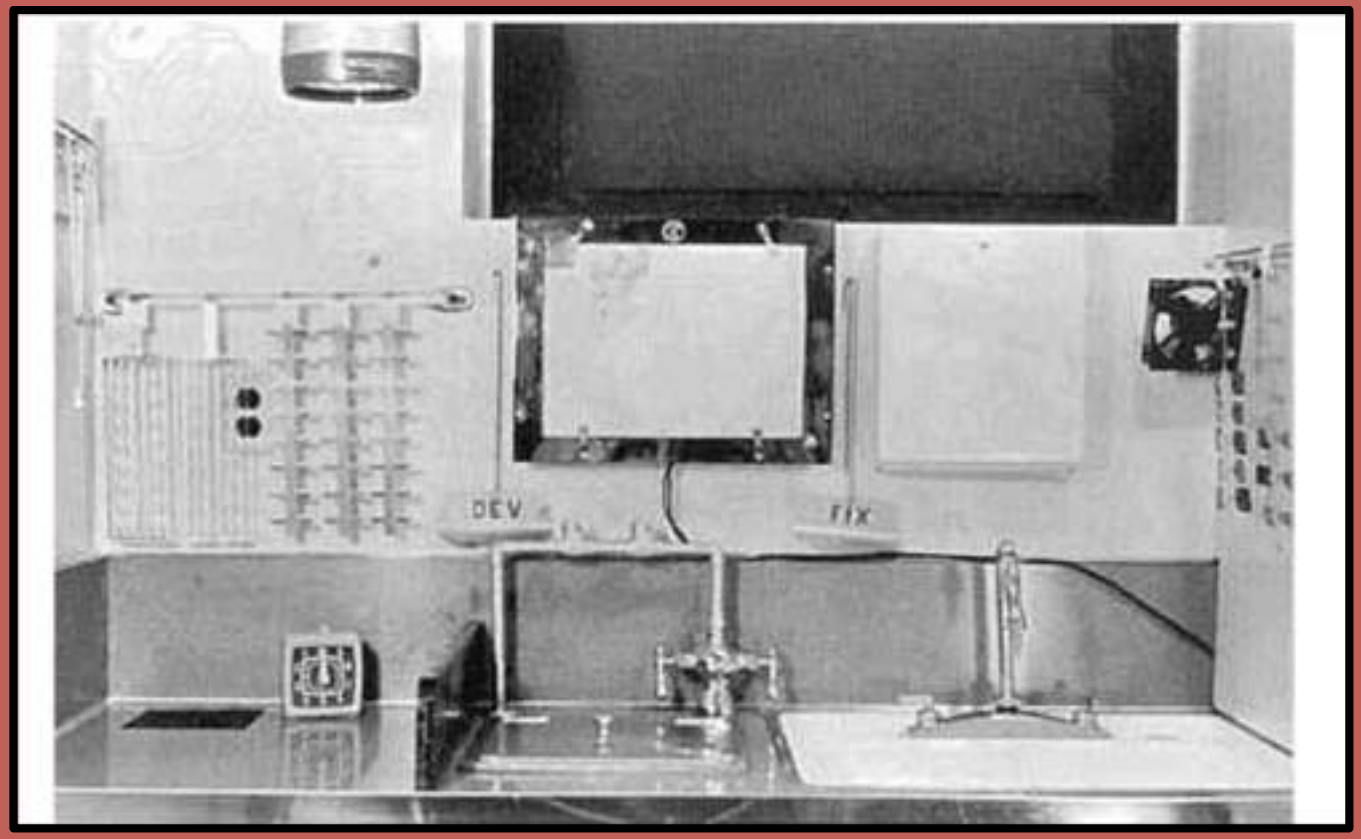


THE DARKROOM

- The primary function of the darkroom is to provide a completely darkened environment where X ray film can be handled and processed to produce a diagnostic image in an efficient, precise and standardized procedure.

General Lay out

- Size : At least 4x5 feet
- Light proof
  - Light tight door
  - Door must have a lock to prevent accidental opening
- Well ventilated
- Should be maintained at comfortable temperature
  - Especially if unexposed films are stored in darkroom(At 90°F or higher temp. there is a generalized increase in film density(film fog)


DEV
FIX

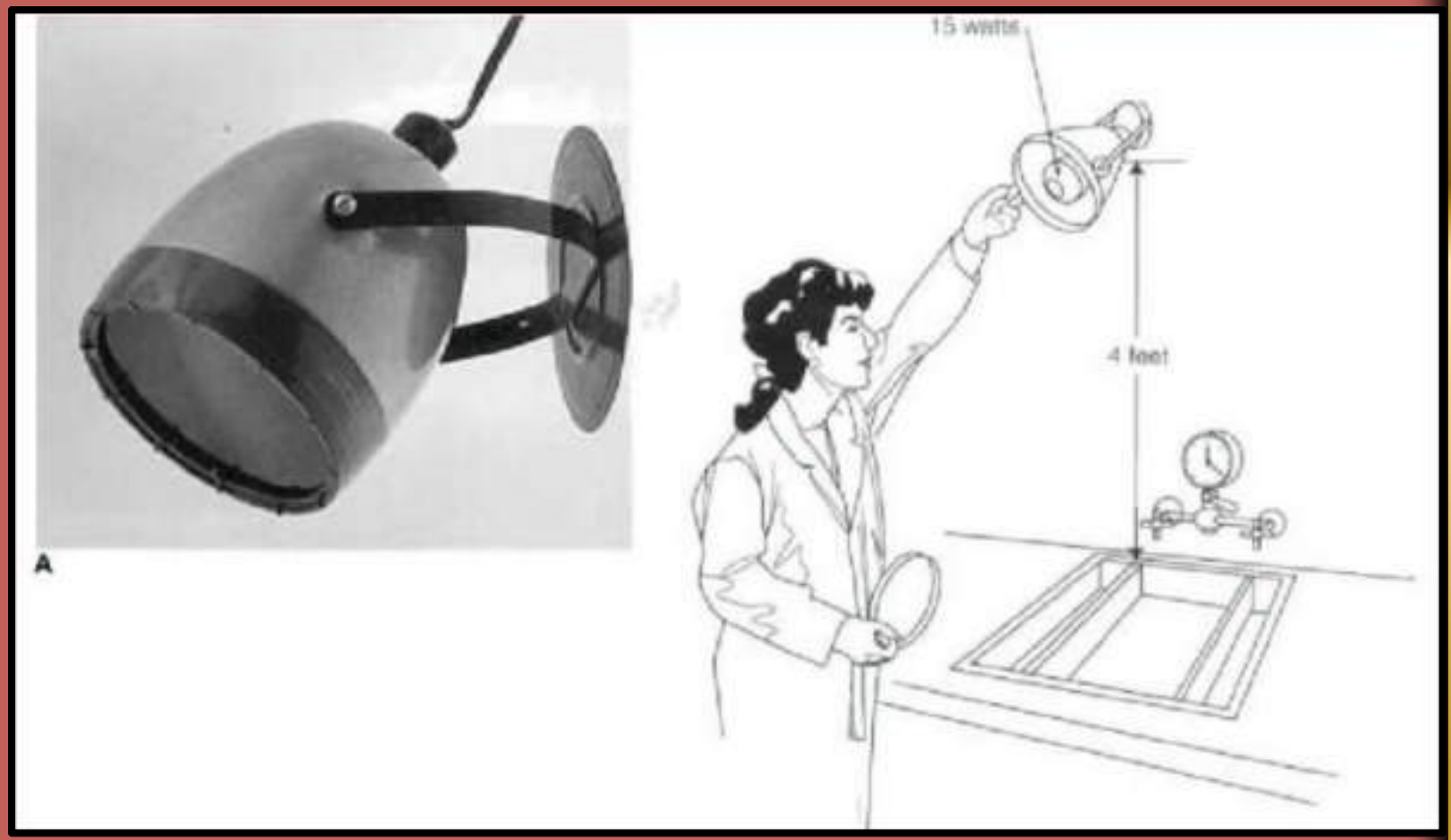
Safe lighting

- **EQUIPMENT:**
  - Dark room must have both white & safe light illumination
  - Safe light is low intensity illumination of relatively long wavelength (orange-red) that does not rapidly affect open film but permits one to see well enough to work in the area.

- Arrangement of safelight filters should be such that three zones of illumination are provided:
  - **Dimmest zone**: Area where the cassettes are loaded and the intraoral film is opened.
  - **Medium zone**: Area where films are developed & fixed
  - **Bright zone**: Area where films are washed & placed in the drier

✓ This arrangement can be accomplished by placing one safelight above the working area and another on the wall behind the processing tanks & somewhat to right in the region of the fixing tank.

- ✓To minimize the fogging effect of prolonged exposure , the safe light should be mounted atleast 4 feet above the surface where opened films are handled.
- ✓A 15 watt bulb should be used except for KODAK SB panoramic film, for which a 71/2 watt bulb is necessary.
- ✓X ray films are very sensitive to blue – green region of the spectrum (relatively short wave length) are less sensitive to the yellow and red wavelengths.

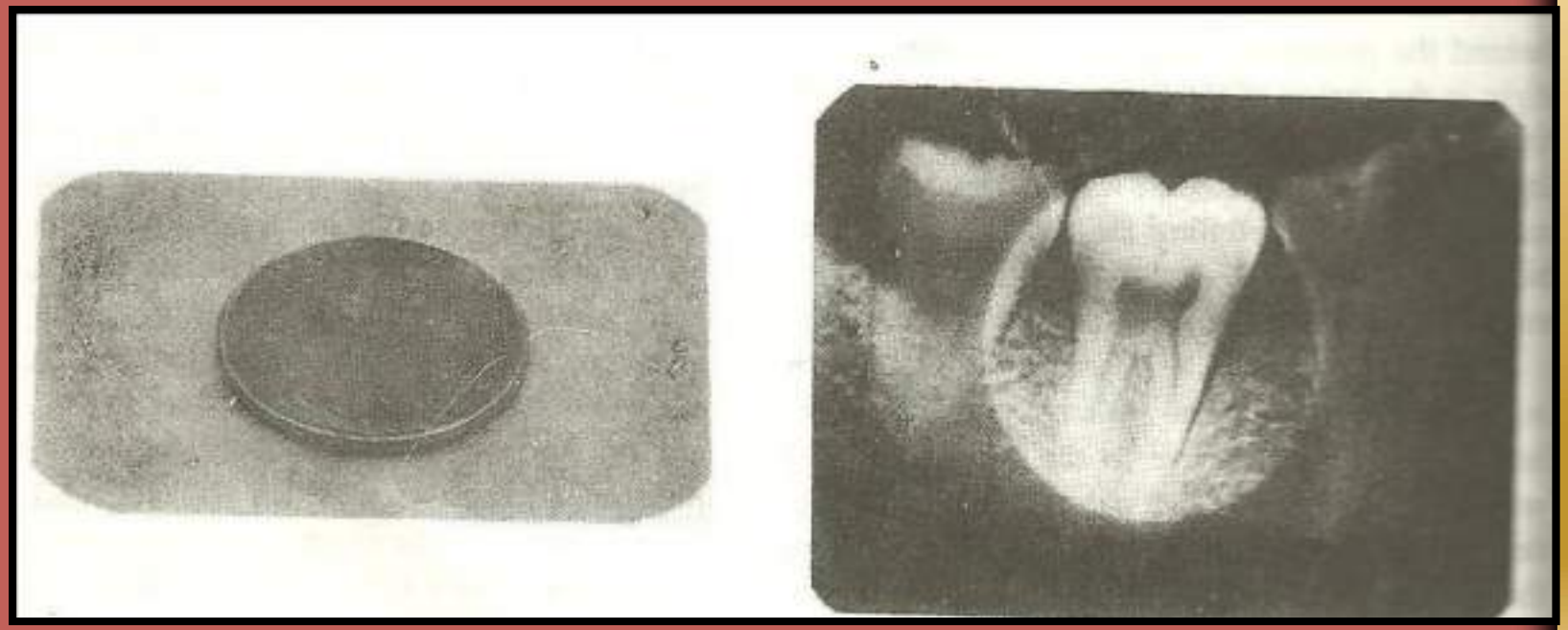

A
15 watts
4 feet

- Because one can see better under yellow and red light , a yellow filter , such as yellow Morlite ML-2 filter by kodak, is reccommended.
- All kodak intraoral dental film is made especially for use with *Morlite filter.*
- This filter can only be used with non screen film.
- All screen films for eg panoramic film , must be used with darker type *GBX-2 filter.*

Test for unsafe illumination

- Film may be fogged in the darkroom by
  - use of inappropriate safelight filters from excessive exposure to safelights or from stray light from other sources.
- **COIN/ PENNY TEST:** It is a test to evaluate for fogging caused by inappropriate safe lighting conditions.
  - Shut all the lights & put on safe lights
  - Open film packet & place the bare film in the area where films are usually unwrapped.
  - Place a coin on the film & leave it in this position for approximately the time required to unwrap & mount a full mouth set of radiographs, usually 5 minutes

- Develop the test film as usual.
- Inference : if image of coin can be seen on resultant film, room is not light safe for the particular film tested.



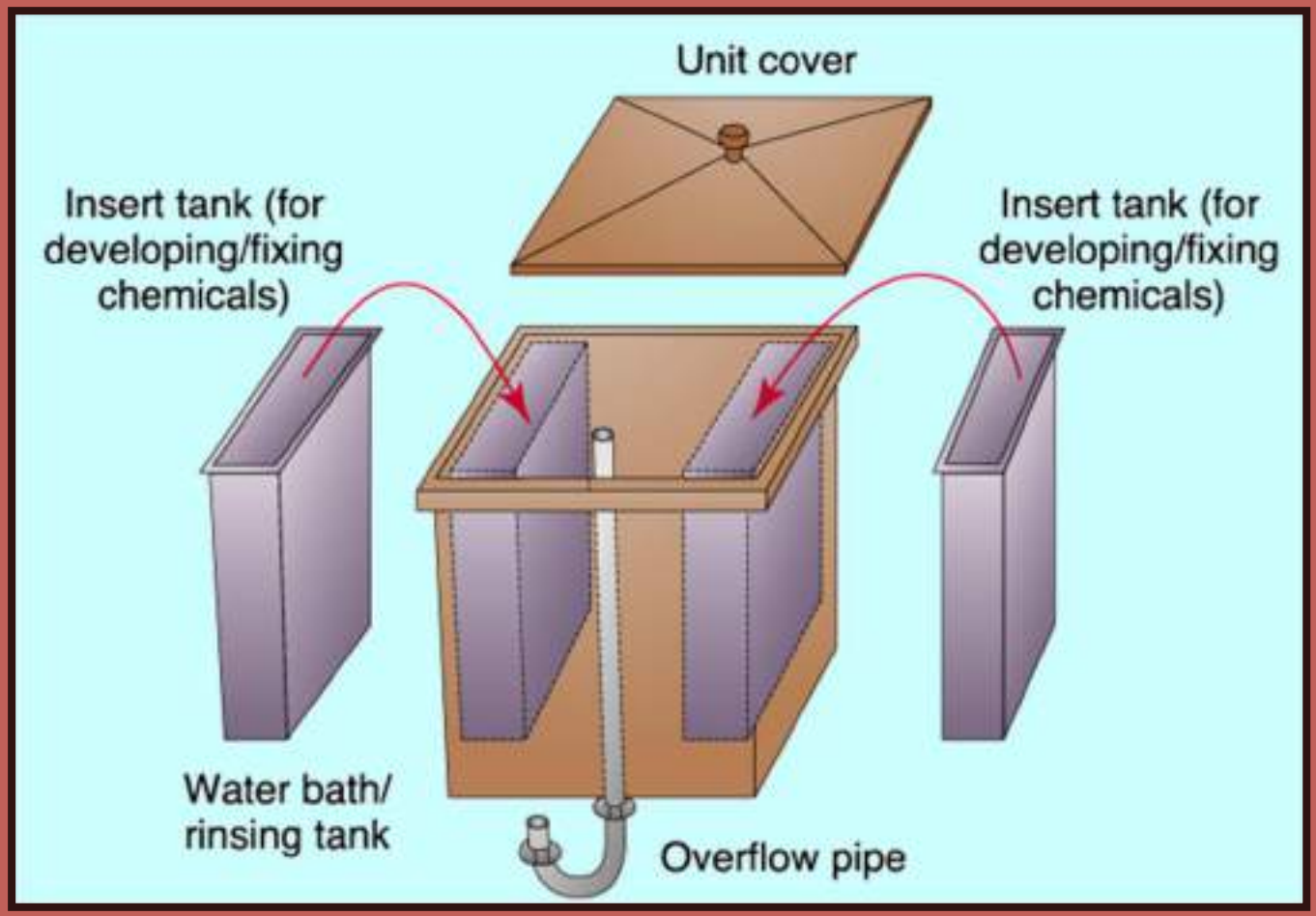
LIGHT LEAK TEST:

- To check whether there is no light leak
- Shut the door & all the light in the darkroom
- 5 minutes (accommodation time) after carefully view all the areas , like periphery of doors & windows to check for any light from outside

PROCESSING TANKS:

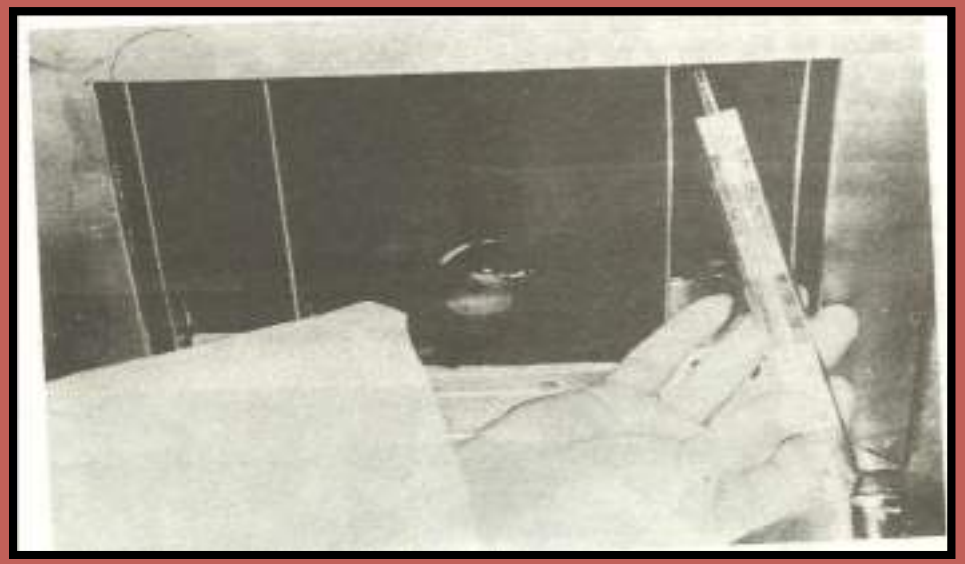
- Dental radiographs are usually are developed by tank processing.
- The tank must be supplied with hot and cold running water and a means of maintaining the temperature between 60ºC and 75 ºF.
- A practical size for a dental office is a master tank of about 20x25 cm (8x10 inches) that serves as water jacket for two removable inserts that fit inside.
- The insert tanks usually hold 3.8 L(1 gallon) of developer or fixer and are placed with the outer, larger master tank.

- The outer tank holds the running water for maintaining the temperature of developer and fixer in the insert tanks and for washing films.
- As a rule , the developer is placed in the insert tank on the left side of master tank, and fixer in the insert tank on the right side.
- All the three tanks should be made of *stainless steel*, which will not react with processing solutions and is easy to clean.
- The master tank should have a cover to reduce oxidation of the processing solutions, protect developing film from accidental exposure to light , and minimize evaporation of processing solutions.


Unit cover
Insert tank (for developing/fixing chemicals)
Insert tank (for developing/fixing chemicals)
Water bath/ rinsing tank
Overflow pipe

THERMOMETER:

- Because the proper temperature of developing , fixing and washing solutions must be critically controlled , a thermometer should be kept in water circulating through the master tank to monitor its temperature.
- The most desirable thermometers clip onto side of the tank or are free floating in the tank.



TIMER

- It is important that x ray film be exposed to the processing chemicals for specific intervals.
- To control the time of development and fixation , an interval timer is indispensable in the darkroom.

DRYING RACKS:

- On convenient area, which could be inside or outside the darkroom , should be two or three wall mounted drying racks on which film hangers can be suspended above drip trays to catch the water that may run off the wet films.

- An electric fan may be used to circulate the air and speed the drying of the films, although it should not be directed on the films.

- In additions , cabinet dryers that circulate warm air around the film and accelerate the drying are also available.

- If dryers are located in the darkroom they should be vented outside the darkroom to preclude high humidity and heat that would be detrimental to any unexposed film stored in the room.


Thank You