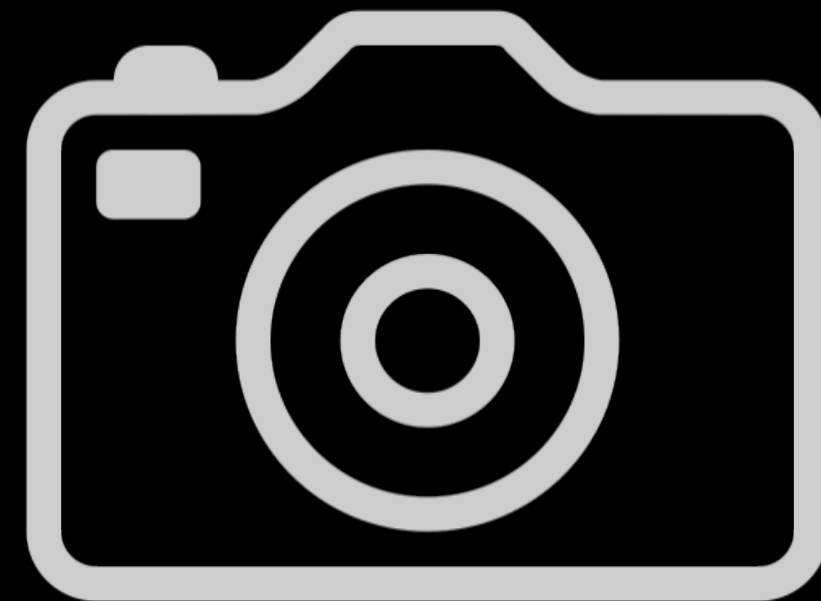# PINHOLE CAMERA

S.T.E.M. Kit

WiTT STEM Kit
Pinhole Camera

- Introduction

- Curriculum Points

- Kit Components

- What a Pinhole Camera is?

- How the image is formed?

- How to build a camera:
    - *Making the Pinhole
    - *Making the Shutter
    - *Loading the Camera

- Exposure:
    - *Variables
    - *Example

- Taking Photos

- Developing Process

- From Negative to Positive

- Going Beyond

What is STEM?

- STEM stands for Science, Technology, Engineering and Mathematics

- The aim of STEM is the integration of these four disciplines together in teaching and learning. As, in the real world, these four disciplines rely heavily and seamlessly on each other.

- STEM helps strengthen key life skills such as analytical thinking, problem solving, creativity, teamwork and technical skills
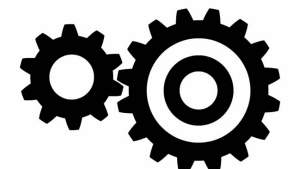
What is WiTT?

- WiTT stands for Women in Technology and Trades

- WiTT is a group that increases opportunities and supports for women in technology and trades in all fields, through a rich networking and support community

- WiTT welcomes industry, staff, students and faculty across all areas of the college and all genders, backgrounds, races and orientation to become involved and contribute to the support of women in technology and/or trades.

Curriculum Points

Grade 9, Scientific Investigation Skills – Part A1 , Page 46 - A1.1 Formulate scientific questions about observed ideas, make predictions, and/or formulate hypotheses to focus inquiries or research

Grade 9, Scientific Investigation Skills – Part A1.5 Conduct inquiries, controlling some variables, adapting or extending procedures as required to collect observations and data

Grade 9, Scientific Investigation Skills – Part A1.8 Analyze and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty.

Grade 10, Chemistry: Chemical Reactions – Part C , Page 76 - C2.1 use appropriate terminology related to chemical reactions

Grade 10, Chemistry: Chemical Reactions – Part C2.3 investigate simple chemical reactions. C2.5 plan and conduct an inquiry to identify the evidence of chemical change.

Grade 10, Physics: Light and Geometric Optics – Part E, Page 80 - E2.1 use appropriate terminology related to light and optics - E2.3 predict the qualitative characteristics of images formed by plane.

Grade 10, Physics: Light and Geometric Optics – Part E3.3 describe, on the basis of observation, the characteristics and positions of images formed by plane. E3.8 describe properties of light, and use them to explain naturally occurring optical phenomena.

KIT COMPONENTS

CAMERA

Qty	Description
1	Cans (soup/chips)
1	Soda can
1	Electrical Tape
1	Black paint

PHOTO DEVELOPMENT

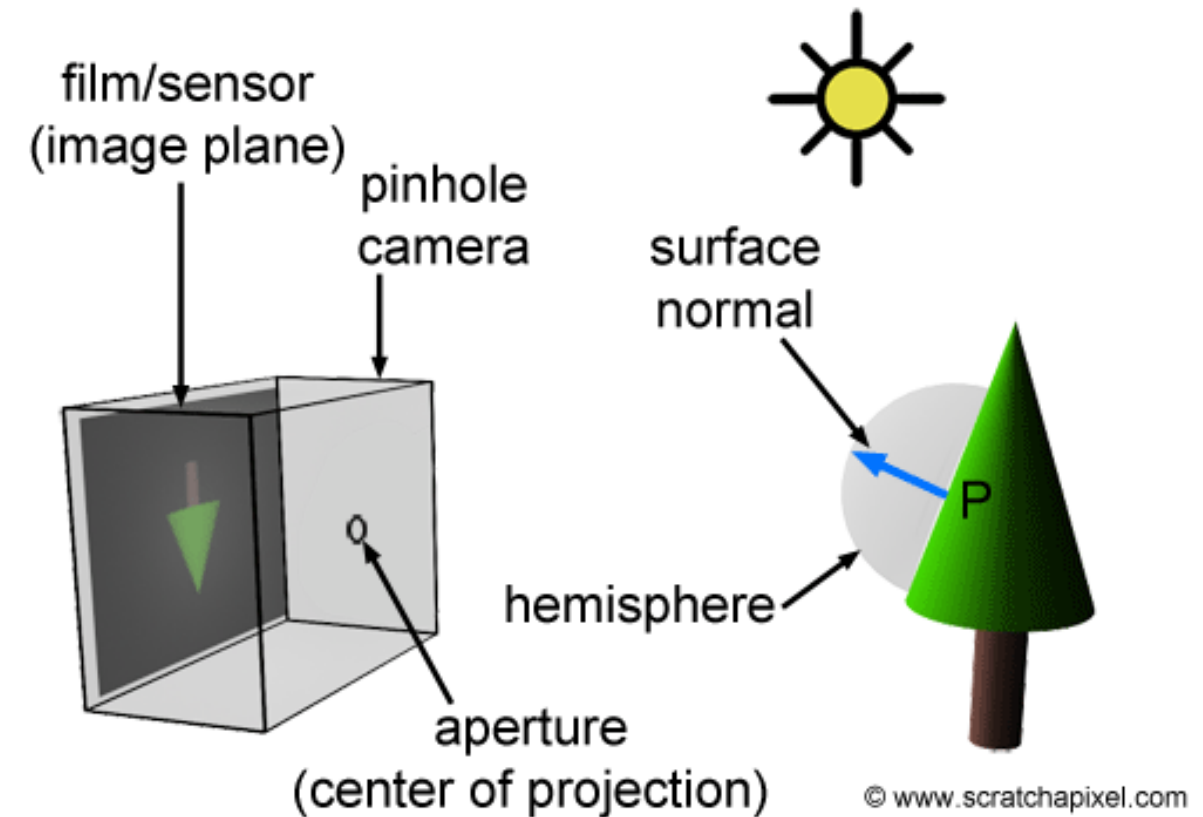| Qty	Description
1	Muligrade Developer
1	Fixer
1	Stop bath
1	Multigrade Photography Paper
# Miscellaneous	Plastic Trays, Water, Tongs, Timer

WHAT A PINHOLE CAMERA IS?

- Is the simplest form of a camera which consist of a light-proof container (can, cardboard box, etc.) with a tiny hole on the middle called pinhole.

- Light passes through the hole reflecting an inverted version of the image from outside.
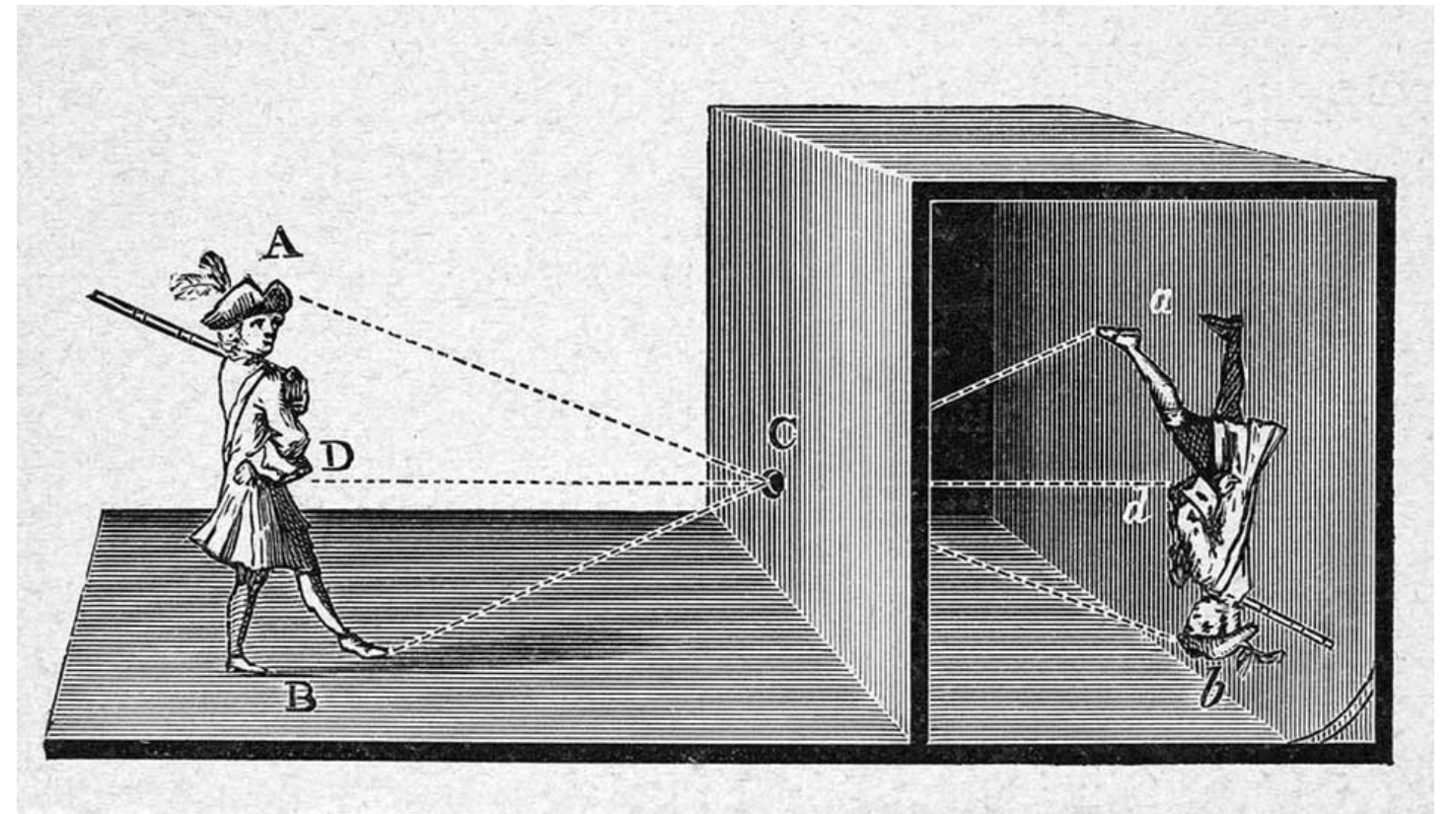
HOW THE IMAGE IS FORMED?

- When the sunlight rays reaches an object, it can be either reflected or absorved.

- The reflected light travels in straight lines and will converge in the pinhole.

- Rays from the top of the image will appear on the bottom of the screen and viceversa. (upside down image)

film/sensor (image plane)
pinhole camera
aperture (center of projection)
surface normal
P
hemisphere
© www.scratchapixel.com

HOW TO BUILD A CAMERA

- A camera can be builded from basically any container whit a lid or a carboard box propely sealed to not allow the light pass through except for the pinhole.

- Inside the camera should be completely painted in black otherwise the light will bounce during the exposure and it will fog the pothography paper.

CONTAINER SHAPE

- Plain back containers will give a normal focal length that means will capture the closest surrounds.

- Curved back containers will provide a wider angle and can even get a kind of panoramic effect.

"The beginner's guide to pinhole photography" by Jim Shull
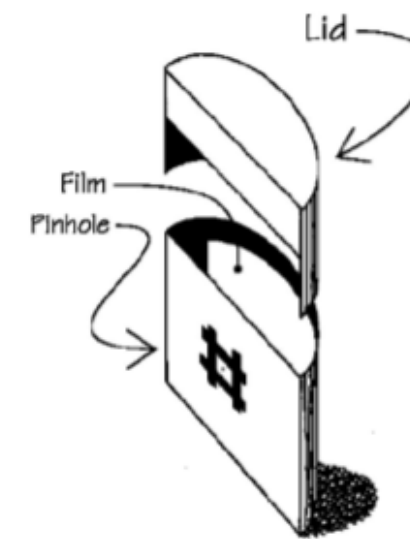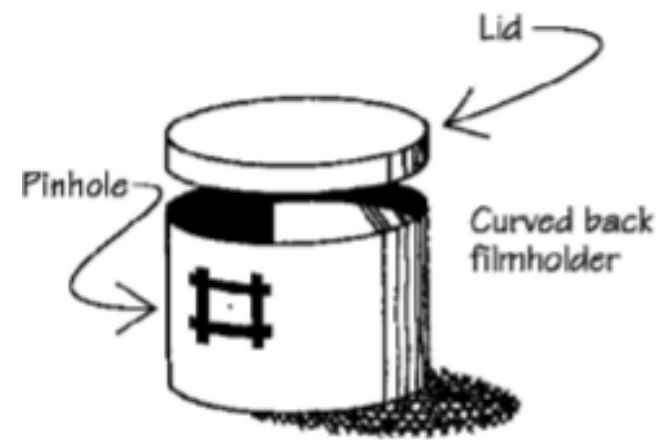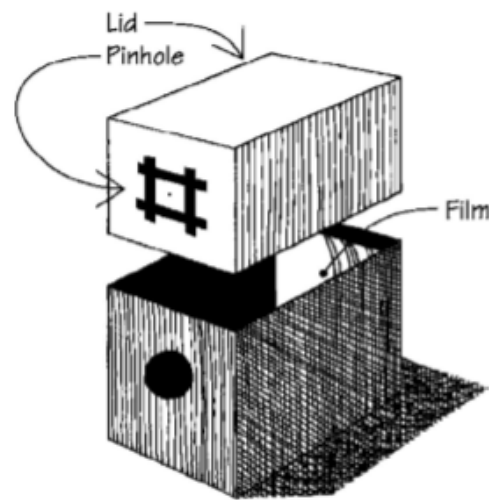
MAKING THE PINHOLE

The pinhole involve two steps:

1- A first hole in the middle of the container must be drilled Φ 0.5 – 1 cm aprox.

2- Cut an aluminium square 2x2cm from the soda can. With the tip of a sewing needle pierce it and then lightly sand it making sure that there is no edges around it.

MAKING THE SHUTTER

- Set the aluminium square in the middle and over the first hole and use black electrical tape for both stick the pinhole and to make the Shutter.

- SHUTTER: is the cover that must be placed over the pinhole and remains closed all the time, only will be opened during the exposure.
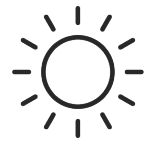
LOADING THE CAMERA

- Once the camera is done, it is time to insert the photographic paper.

- Load the paper in a darkroom with the help of a red safelight to avoid fogging the paper.

- Make sure the "glossy" side of the paper is faced and centered in front of the pinhole, the can is completely closed and the pinhole is covered with the shutter.
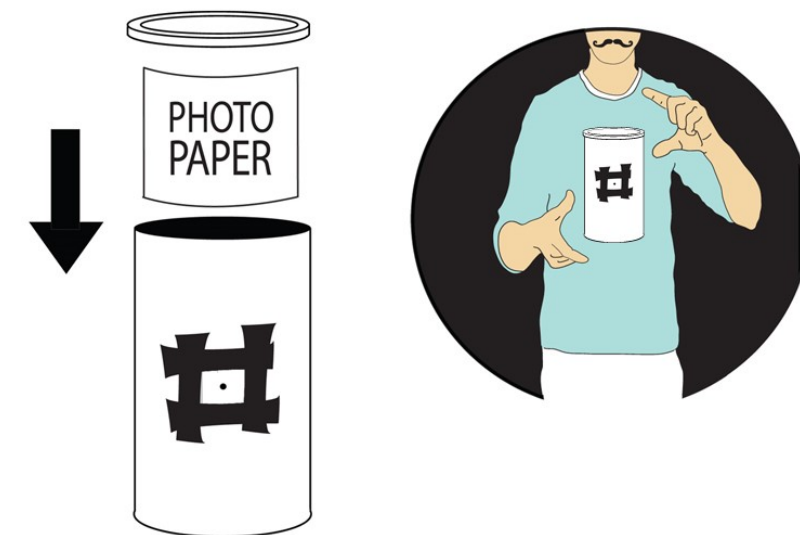
EXPOSURE Variables

- *Light*
Depends on the weather conditions.
The sunnier the better as it needs less time of exposure.

- *F - Stop*
Is the size of the aperture, expresed as the ratio of the distance from the pinhole to the paper (best focal length) over the pinhole diameter (made with a needle).

F-stop values are shown in the following table according to "The beginner's guide to pinhole photography" by Jim Shull.

EXPOSURE Example

A general purpose sewing needle has an average diameter of 0.018"

Then the best Focal Length should be 5" resulting and f-Stop of f/280.

$$f = 5" / 0.018" \approx 280$$

Once determined the f-Stop, then it can be determined the time to keep opened the pinhole.

Needle no.	Diameter	Best Focal Length	f-Stop
4	.036"	20"	f/550
5	.031"	15"	f/490
6	.029"	13"	f/450
7	.026"	10"	f/390
8	.023"	8"	f/350
9	.020"	6.5"	f/300
10	.018"	5"	f/280
12	.016"	4"	f/250
13	.013"	2.5"	f/190

EXPOSURE Example

Any f-stop value >f22 requires the calculation of a multiplication factor to get an equivalent time that can be measured.

This is because light meters does not measure values bigger than f22.

A reference of a f-stop value equal to f16 is taken as a camera in a sunny day works at that value.

The factor calculation is as follows:

$$factor = (280 / 16)^2 = 306.3$$

EXPOSURE Example

Which means that the time for f16 should be multiplied by 306.3 in order to get the exposure time for the f280 that is the measure for the pinhole camera.

Then, (0.25 sec) * (306.3) = 77 seconds are required for exposure.

F-Stops

| 4	5.6	8	11	16	22	32	45	64	90	128	180	256	360	512
1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	6	16	32	64	128	256

Shutter Speeds (in seconds)

TAKING PHOTOS

- A well exposed photo have balanced details in both highlights, midtones and shadow areas.

- Underexposed: lighter imagethen. Add 10 seconds more to the exposure time.

- Overexposed: darker image and might need less exposure time.

- Making notes of the paper type, the time of day, and the exposure time will help to get a reference for the next time to use the camera.

DEVELOPING PROCESS

- To develop the photo the camera must be taken back to the darkroom to take out the paper. The photography paper still white.

- Three trays must be prepared: 1- Developer   2-Fixer   3-Stop Bath

- Each component must be prepared as a solution with water and should be enough to fill the tray about half full in depth and to cover the paper completely during the proccess. The recommended developing temperature is 20°C.
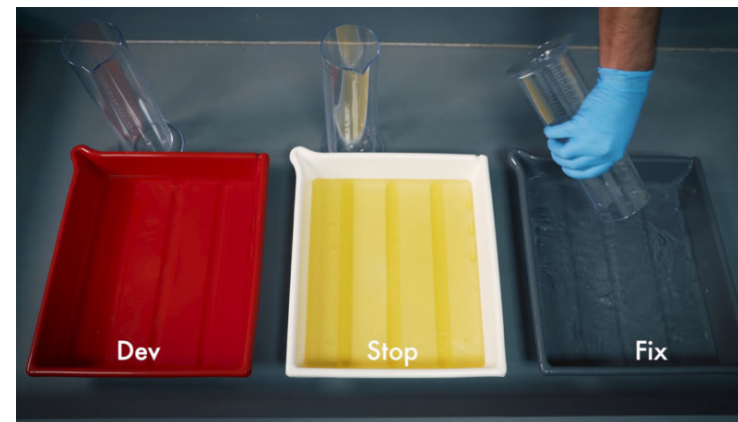

Solution	Dilution	Time
Developer	1:9	1 min
Fixer	1:9	1 min
Stop	1:19	10 sec

DEVELOPING PROCESS

- This is how the layers of a photography paper looks like.

- A latent image is already formed in the photo-sensitive emulsion by the interaction between Bromide (Br) and Silver (Ag)

- Sunlight photons strike the paper causing an electron from bromide ion goes into the positive silver ion and its combination forms a metallic atomic silver.


$$Ag^+Br^- \xrightarrow{h\nu} Ag^+Br^0 + e^- \text{ (trapped by AgS)}$$
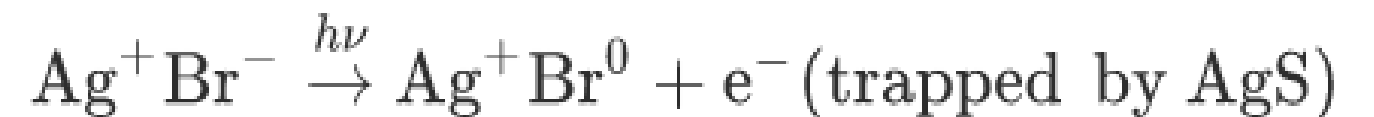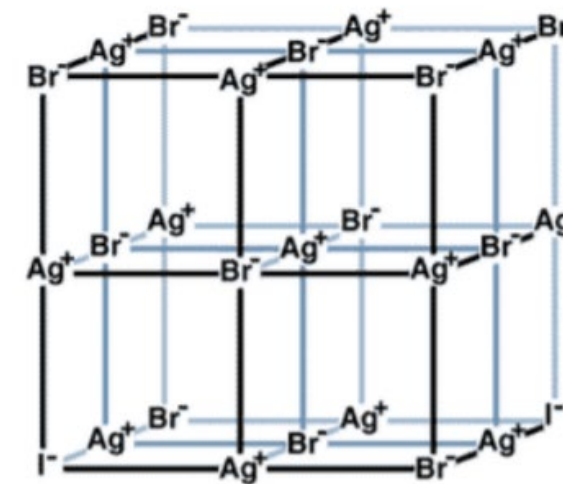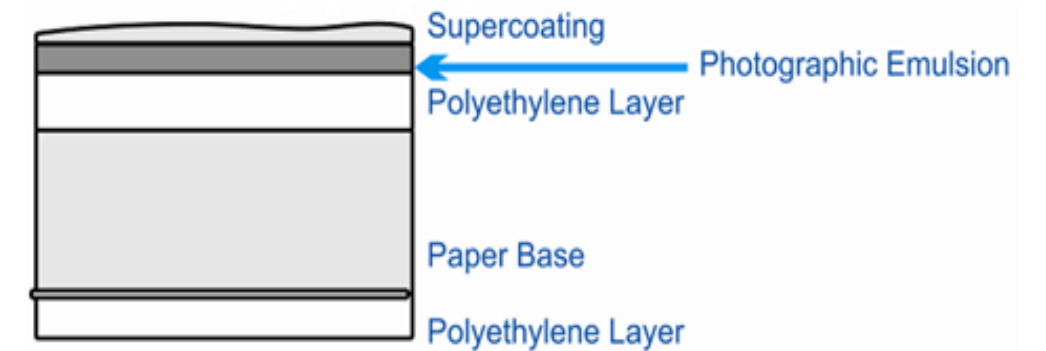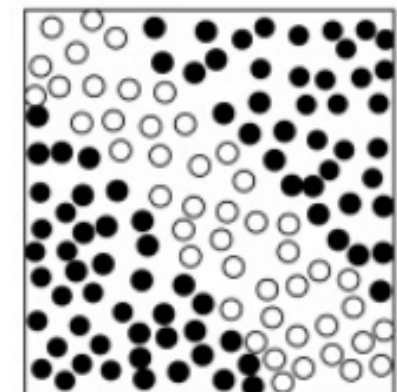
DEVELOPING PROCESS

• **Developer:** is an organic reducer agent.
Metallic silver that forms the latent image is reduced by the quinones (alkaline pH). The higher the alkalinity the faster the development.

• **Stop bath:** composed of acetic acid.
Stops the development and the reactions by acidifying the solution for the fixation process.

• **Fixer (S_2O_2):** used to remove the silver salts that are either unexposed or undeveloped and leaves the reduced silver on the paper. Makes the image permanent.

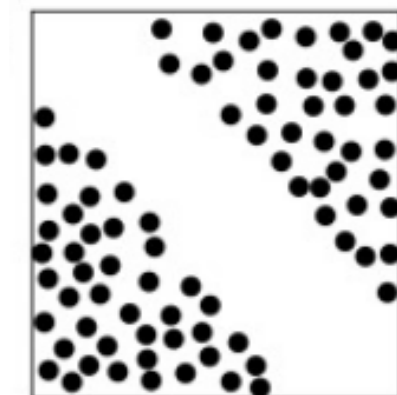$$AgBr + Na(S_2O_2)^- \rightarrow Ag(S_2O_2)^- + NaBr$$

Latent image
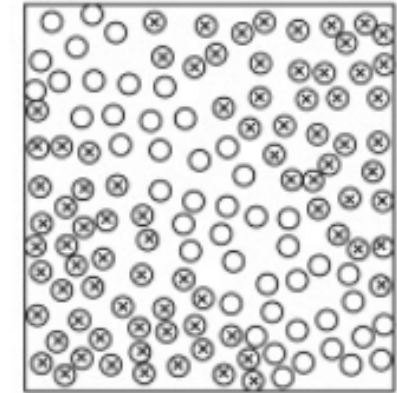
Developed film

Fixed film

DEVELOPING PROCESS

- Finally, the photography paper is rinsed by running water from the tap during 2 minutes aprox. to eliminate the remaining unprocessed silver and fixer.

- Subsequently the paper must be dried by hanging it or laying it on a paper towel for a couple of minutes.

FROM NEGATIVE TO POSITIVE

- The developed image that you get from the pinhole camera is indeed a negative version of it.

- Negative means that shadow areas will be light and light areas will be dark.

- To convert negative images to positive:
1. Take a digital picture of your paper photo or scan it.
2. Use software such as:

<div align="center">

Adobe Lightroom

RawTherapee

Capture One

Darktable

</div>

FROM NEGATIVE TO POSITIVE

- Here is a demo video with Lightroom

GOING BEYOND ?

This kit also can be explored by:

* Varying the exposure time and comparing the results that you get after developing the photo paper.

* Taking photos with different shaped containers to see how it influence on the pictures.

* Comparing how the light impact on taking photos: outdoor and indoor shots, sunny or cloudy days.

* Testing with in motion backgrounds that means where people or objects are moving while others stand still.

THANK YOU !

For more S.T.E.M. learning resources or additional information please visit our website.

https://www.mohawkcollege.ca/about-mohawk/cyber-security/science-technology-engineering-and-math-stem-learning-resources