

RECOVERING CONTRAST IN DOCUMENTS USING OPTICAL METHODS

(or Physics + History = Phystory)

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AN INTERESTING QUOTE, AN INTRODUCTION TO LIGHT, AND SOME EXPERIMENTAL STUFF

"Light brings us the news of the Universe. Coming to us from the sun and the stars it tells us of their existence, their positions, their movements, their constitutions and many other matters of interest. Coming to us from objects that surround us more nearly it enables us to see our way about the world: we enjoy the forms and colours that it reveals to us, we use it in the exchange of information and thought."

From: The Universe of Light by Sir William Bragg

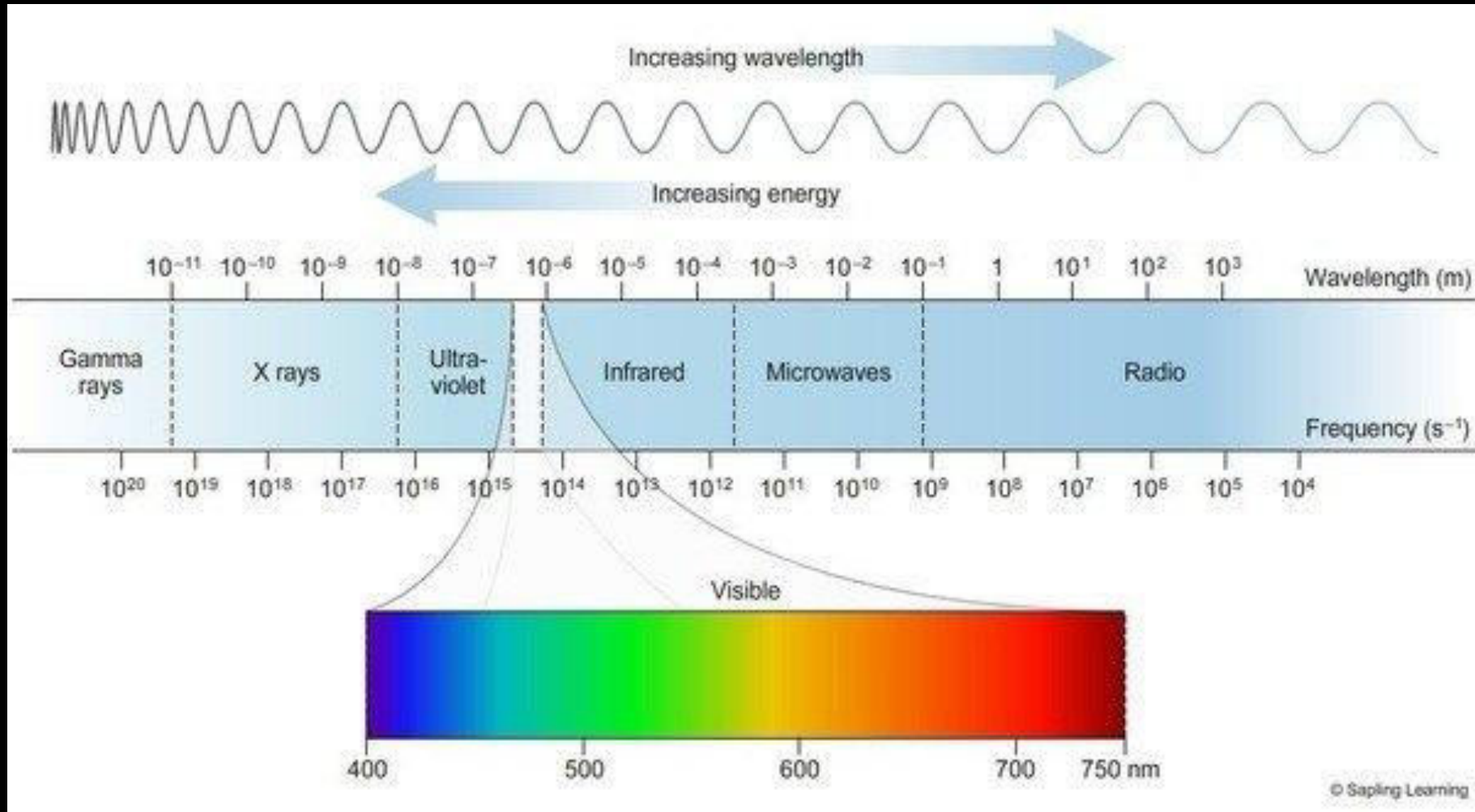
WAVELENGTH

(USED TO DESCRIBE COLOUR OF LIGHT)



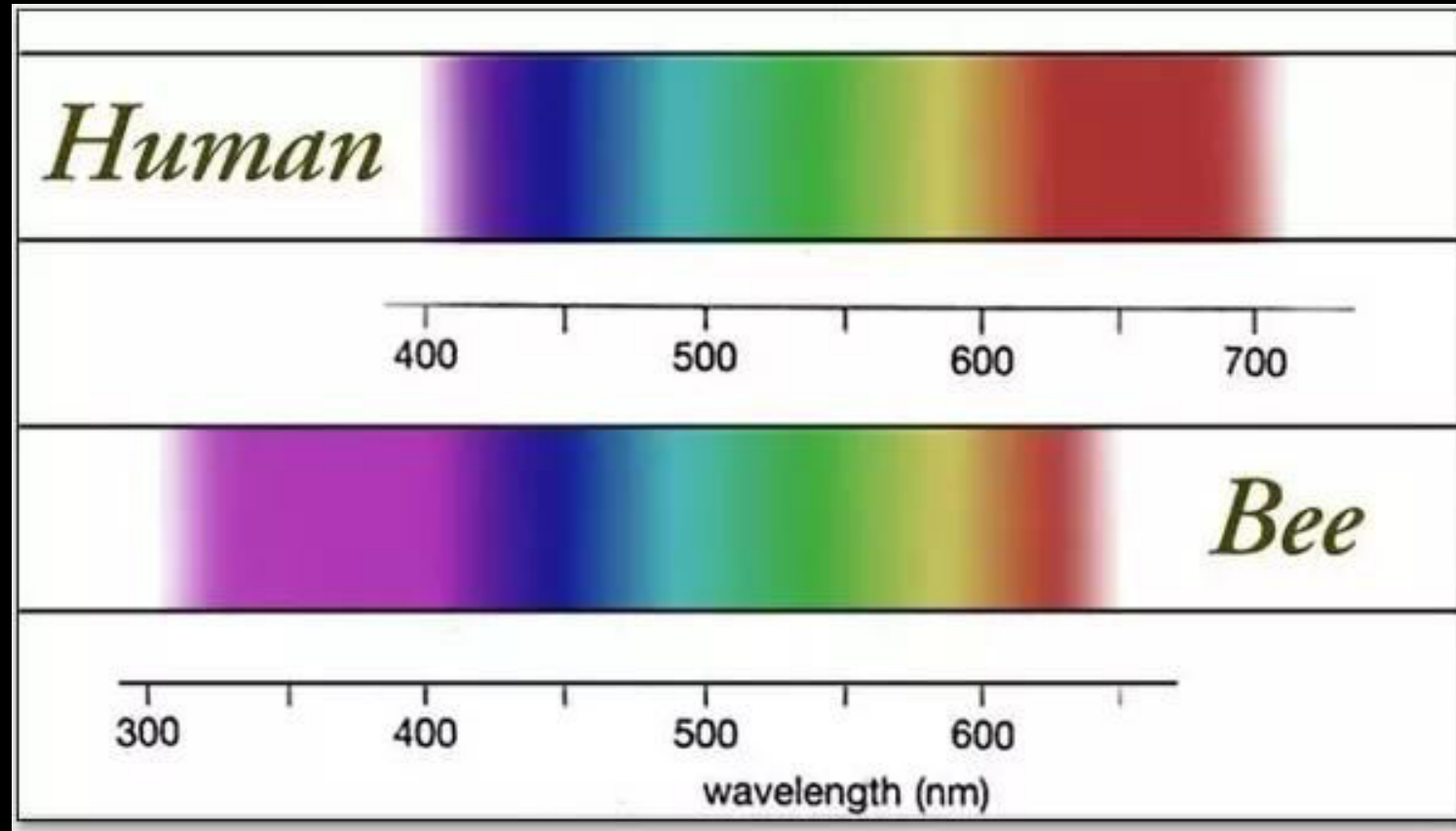
<https://www.surf-forecast.com/breaks/Ria-Foz/photos/6674>

ELECTROMAGNETIC SPECTRUM

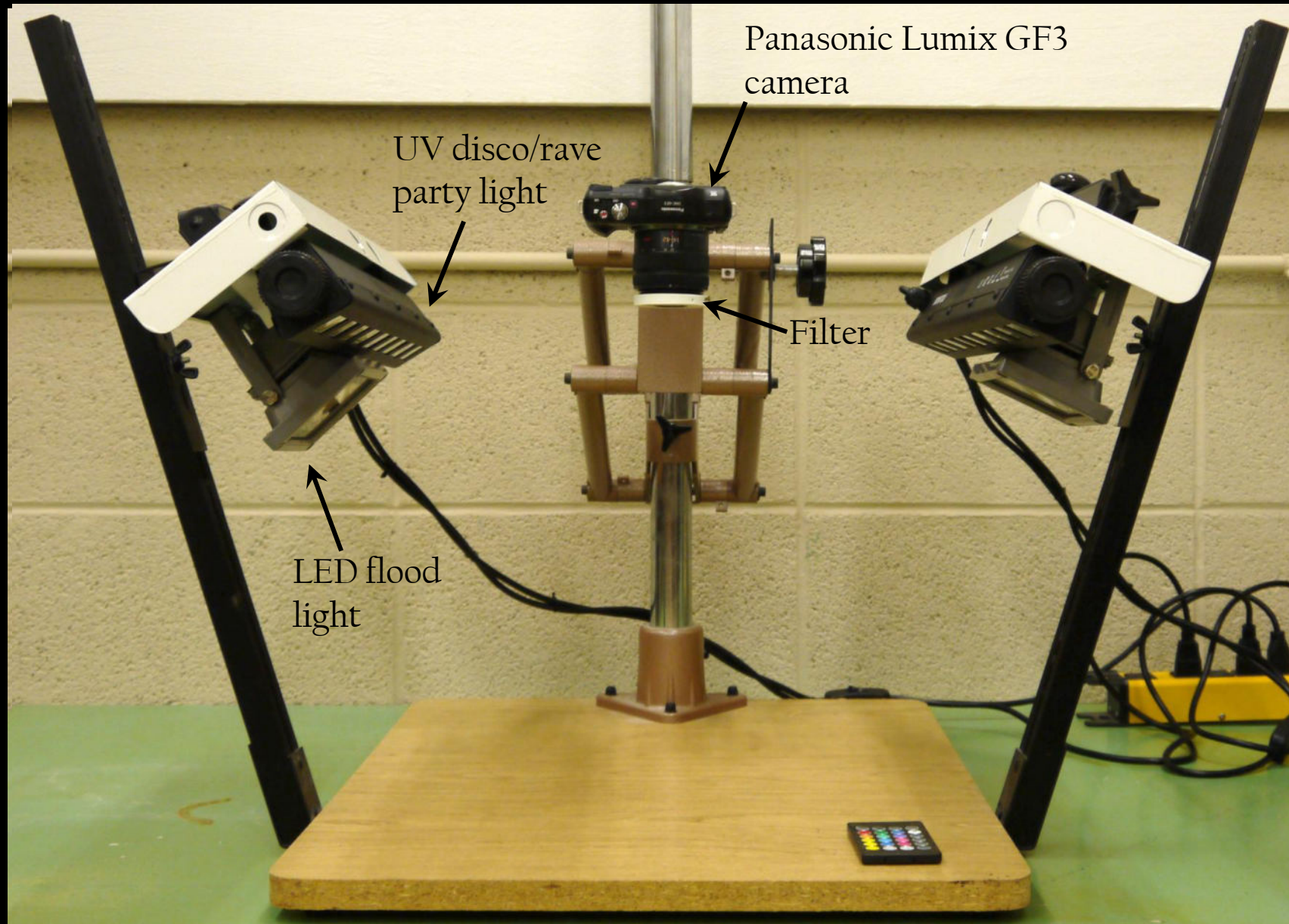


<https://www.quora.com/What-are-the-frequencies-in-the-visible-spectrum>

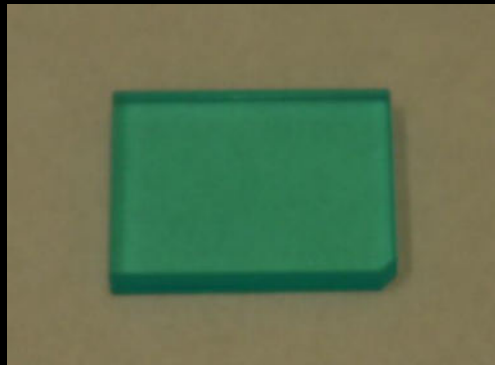
HUMAN VS BEE SPECTRAL VISIBILITY RANGE



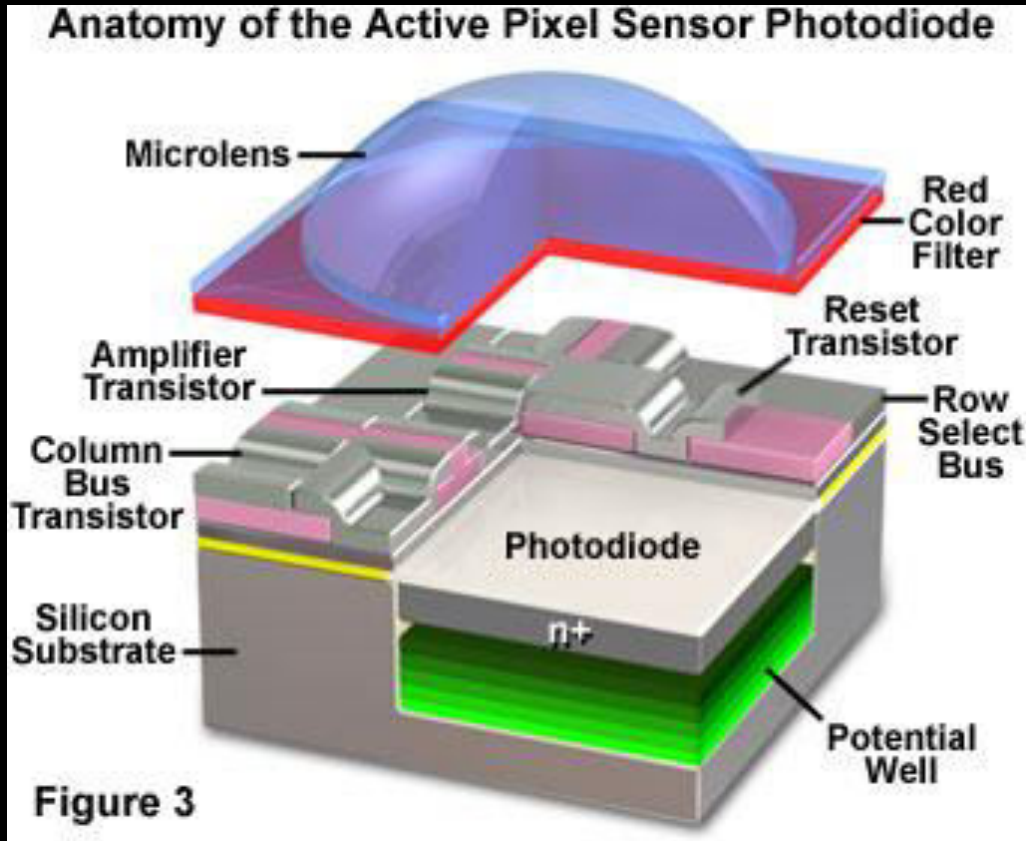
EQUIPMENT



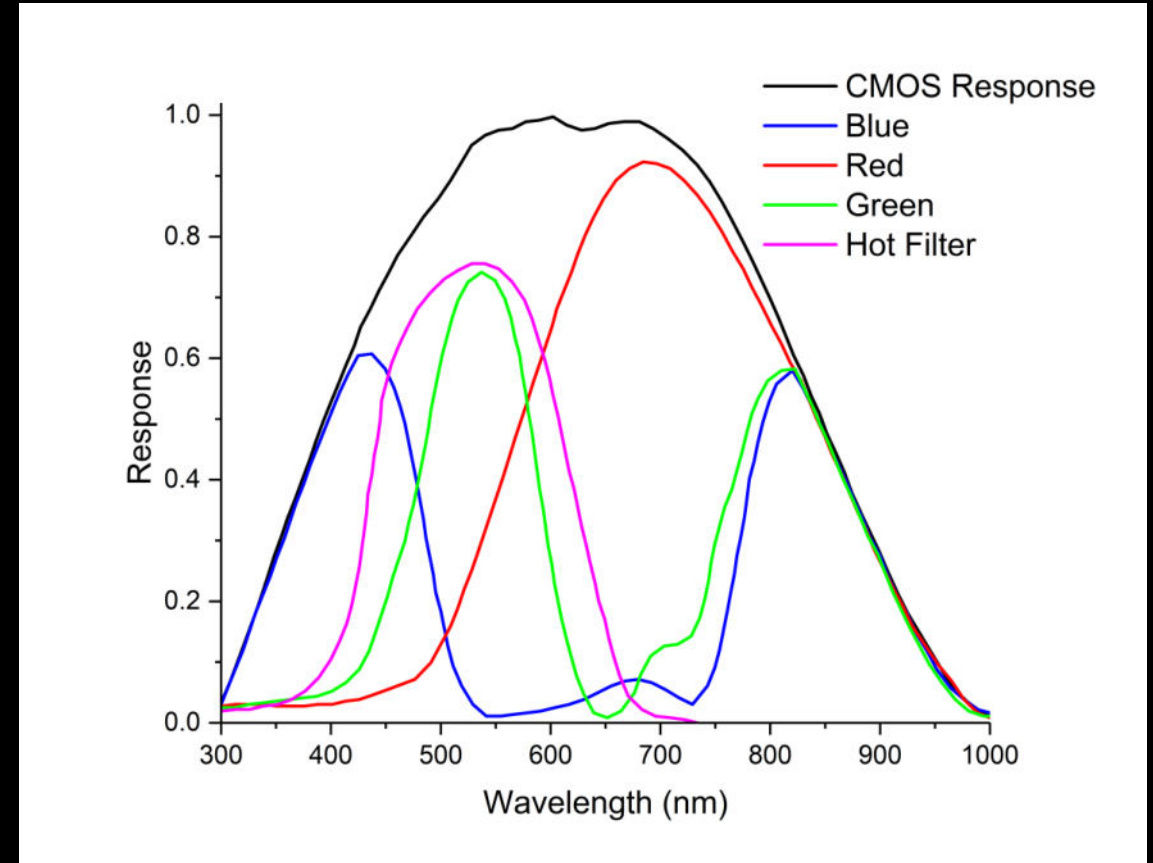
CAMERA



CAMERA



The structure of a single pixel in a CMOS image sensor.
<https://micro.magnet.fsu.edu/primer/digitalimaging/cmosimagesensors.html>



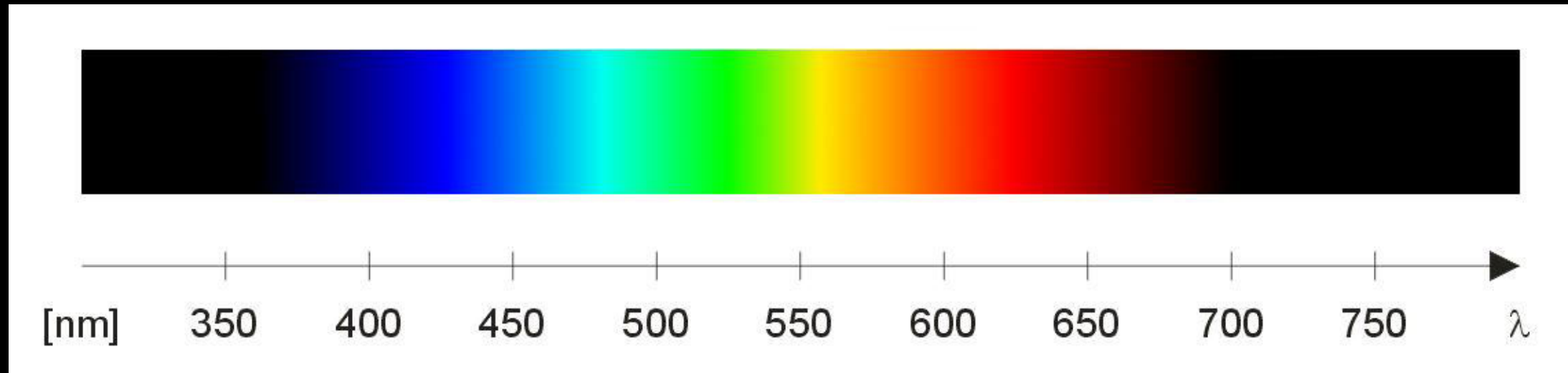
Wavelength response of a CMOS digital camera image sensor and each of the filters typically present in colour cameras.

SPECTRAL RANGES OF CAMERAS USED

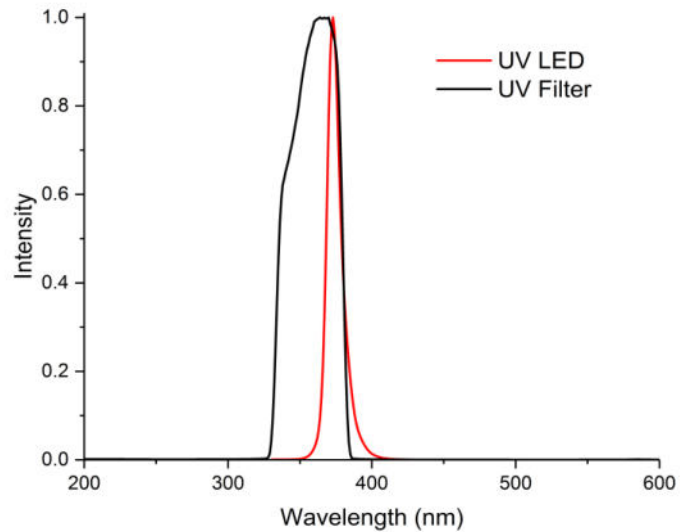
Modified Camera

1000 nm

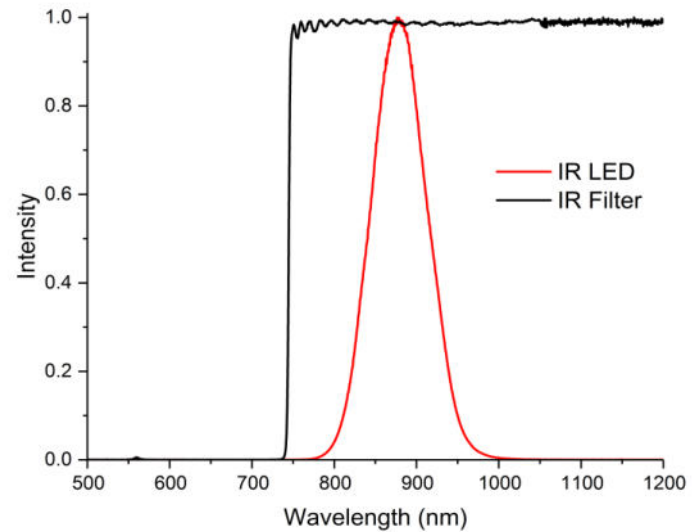
Normal Camera



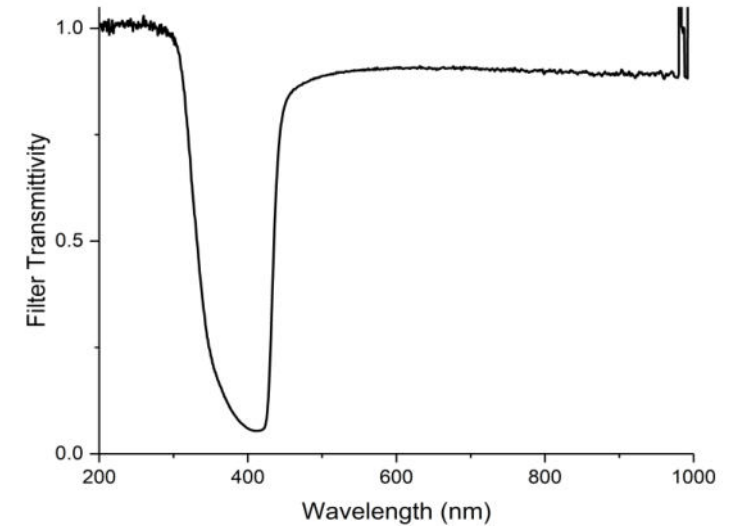
FILTERS AND LIGHT SOURCES



Ultraviolet – 365 nm LED and
357 nm filter

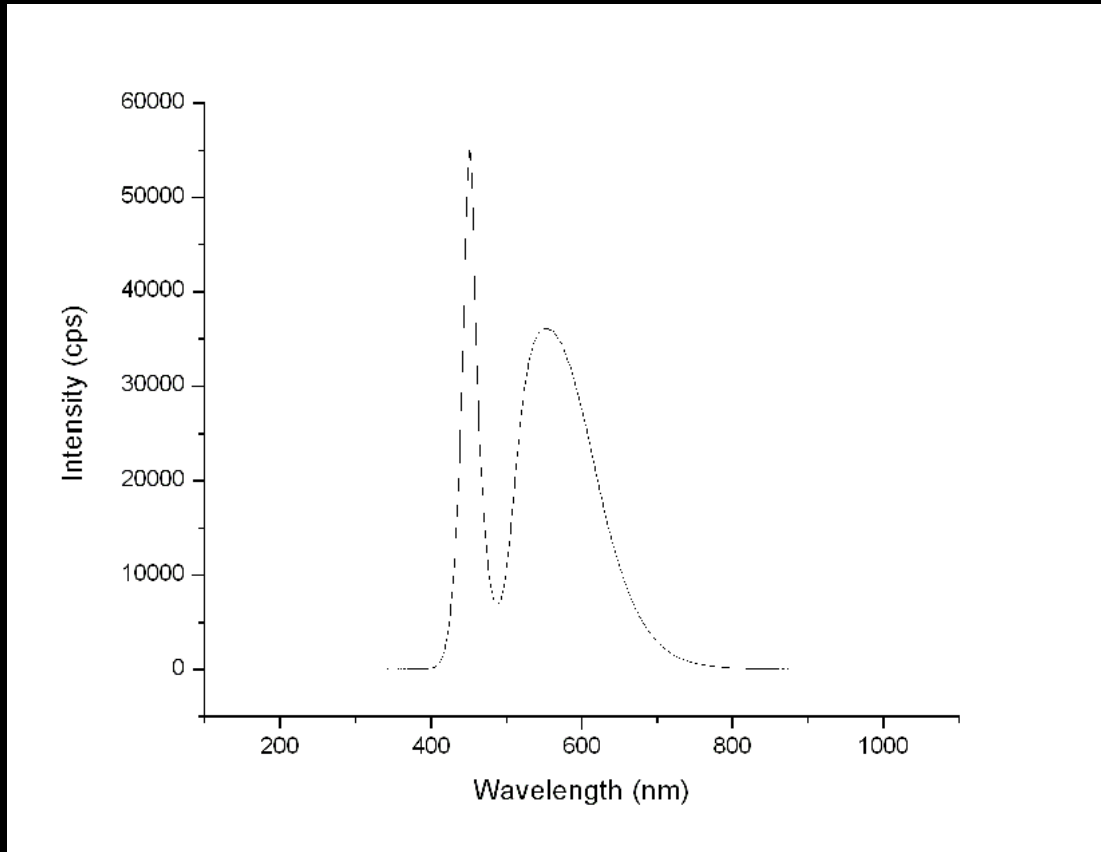


Infrared – 888 nm LED
and 745 nm filter

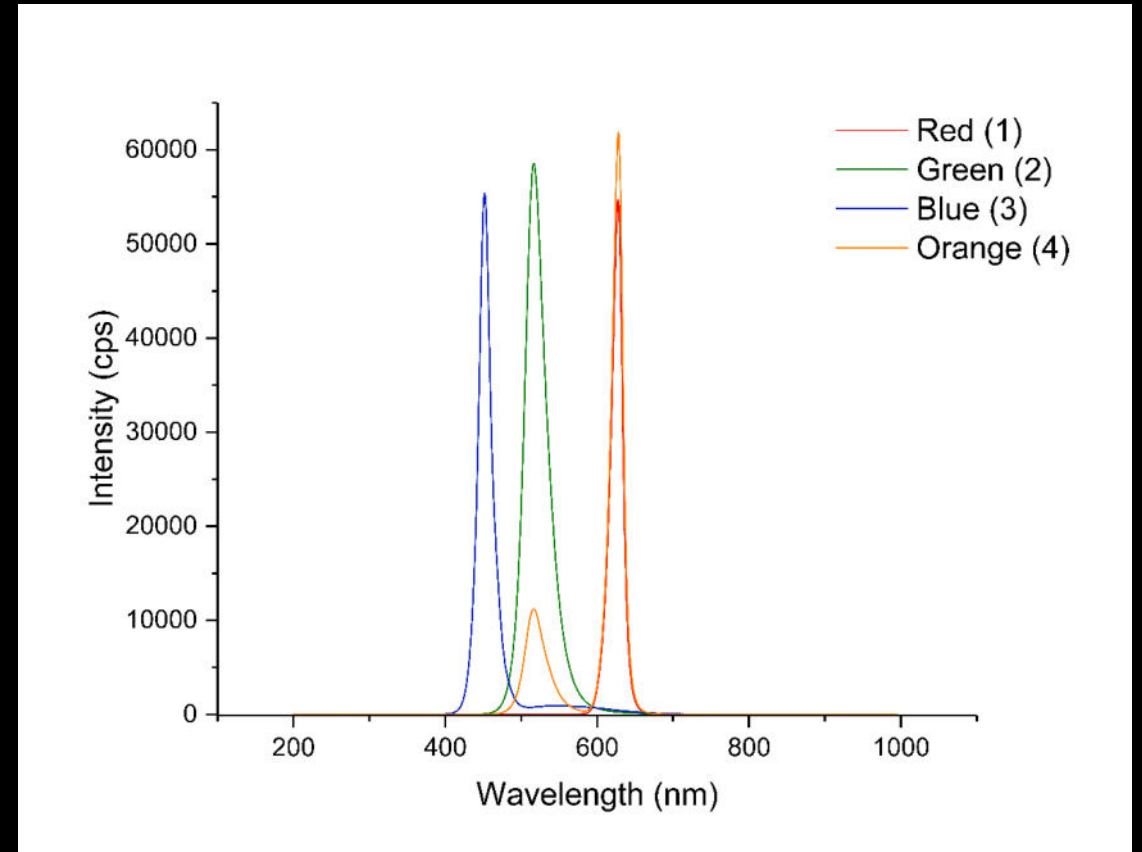


UV block filter – blocks
300-450 nm

FILTERS AND LIGHT SOURCES

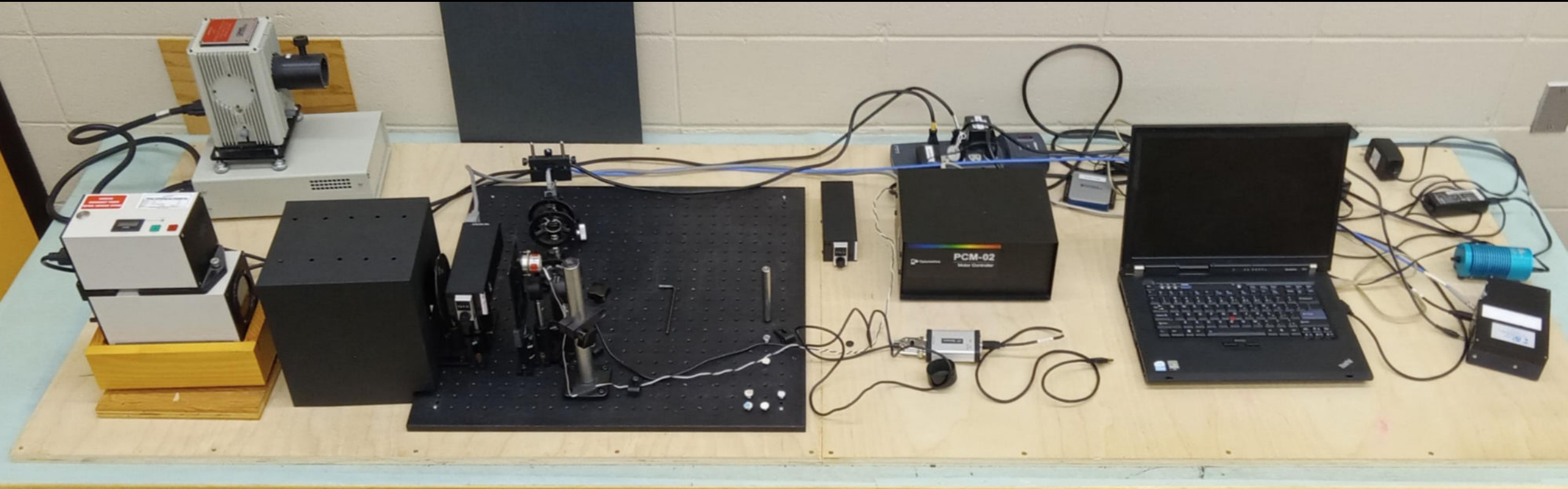


White LED spectrum



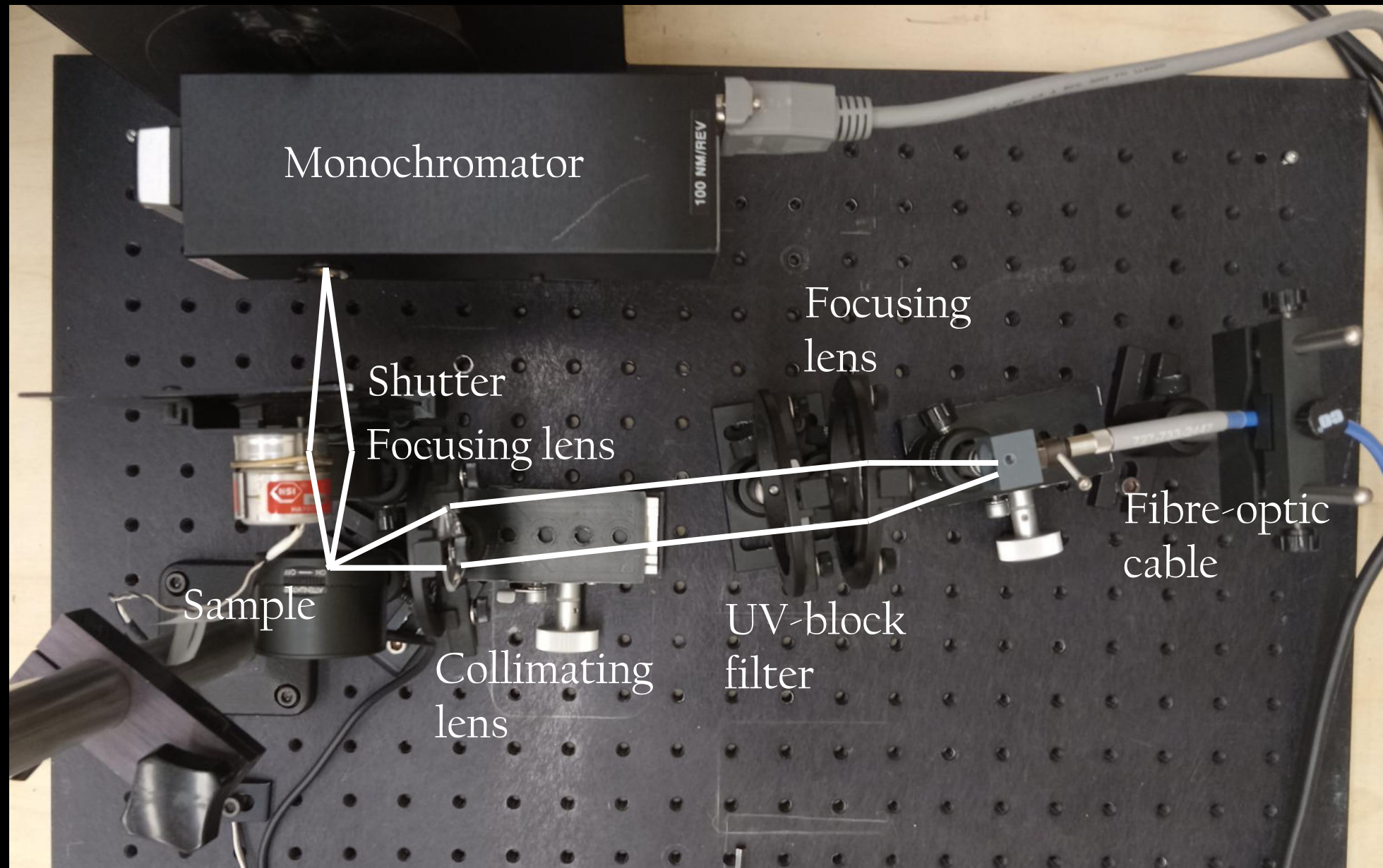
Visible color LED spectra – red (628 nm), green (516 nm), blue (452 nm), orange

SPECTROSCOPY APPARATUS



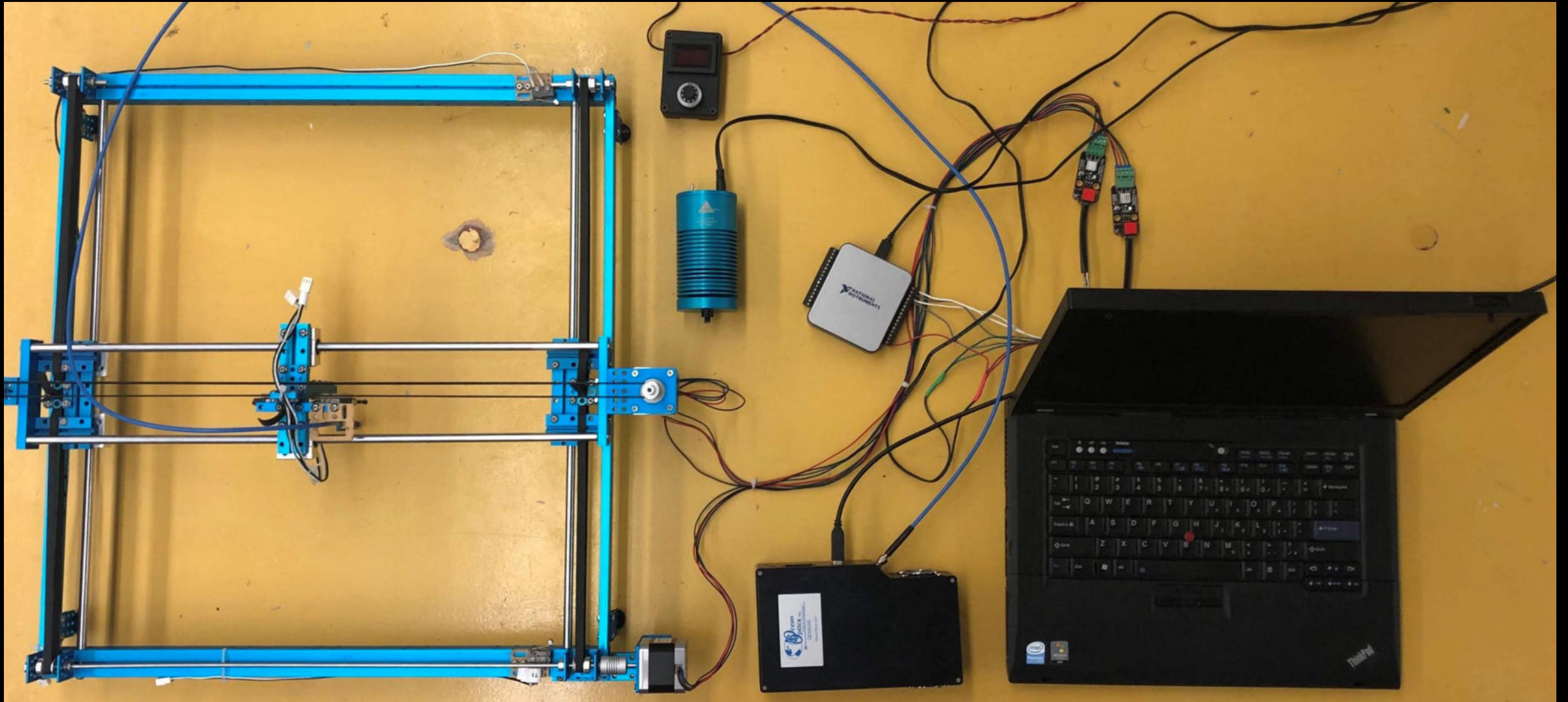
Ocean Optics QE65000 based excitation spectroscopy system used to create luminescence, transmittance, excitation, and emission spectra.

SPECTROSCOPY APPARATUS



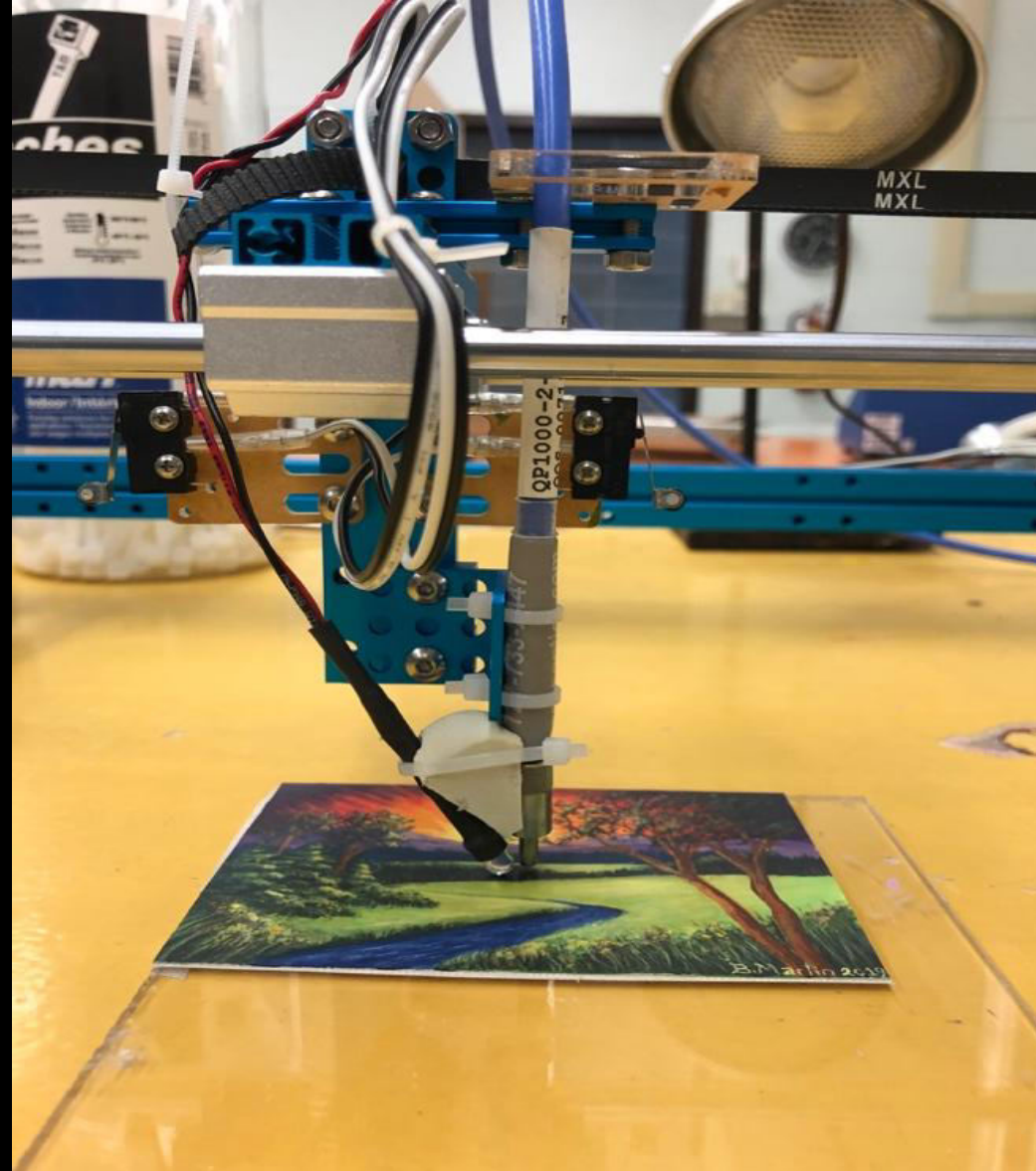
SCANNING IMAGING SYSTEM

1550 NM LIGHT



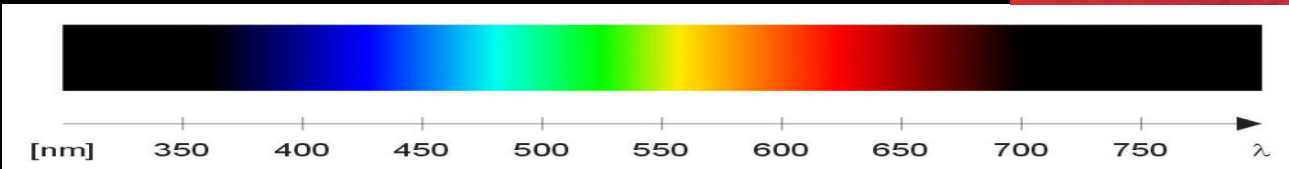
SCANNING IMAGING SYSTEM

1550 NM LIGHT



WHAT CAN WE SEE IN UV-VIS-IR?

Infrared light

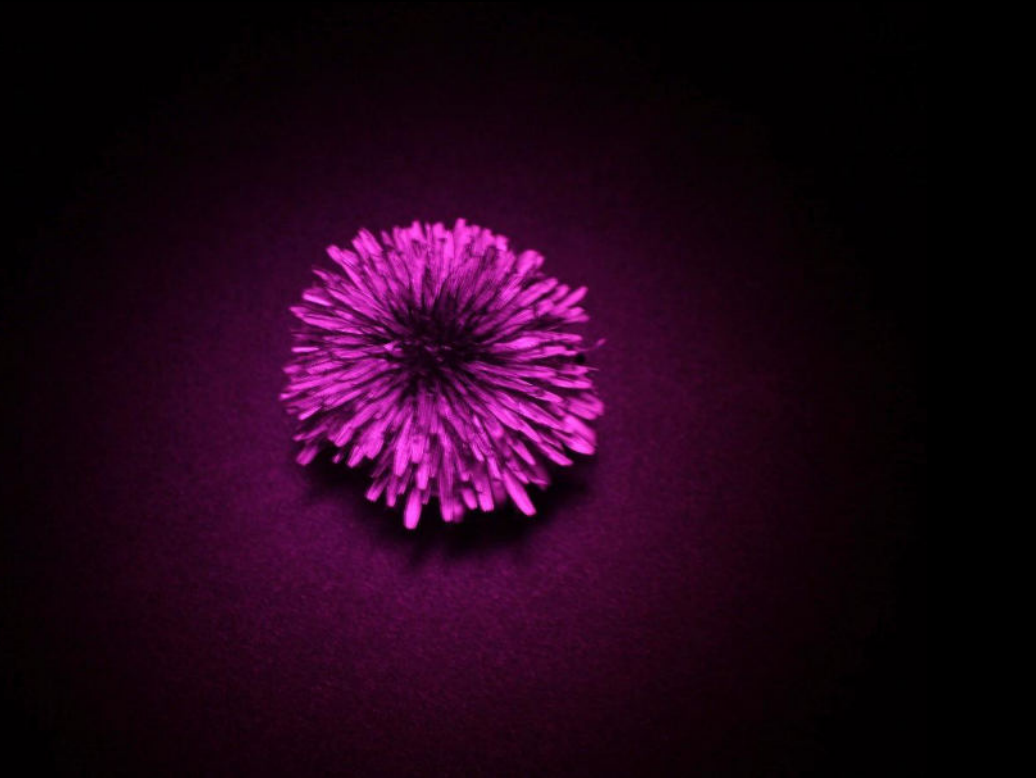


WHAT CAN WE SEE IN UV-VIS-IR?

Visible light



UV light

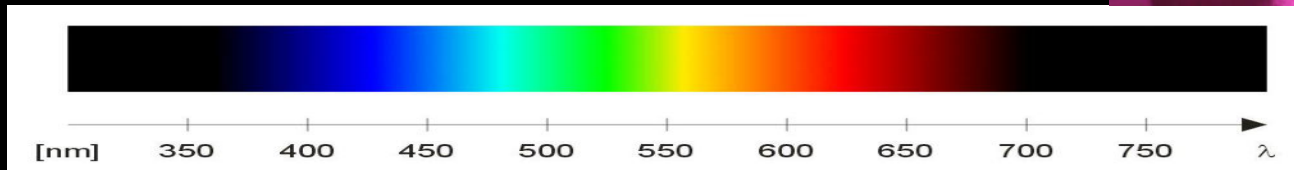


WHAT CAN WE SEE IN UV-VIS-IR?

Ultraviolet light



—

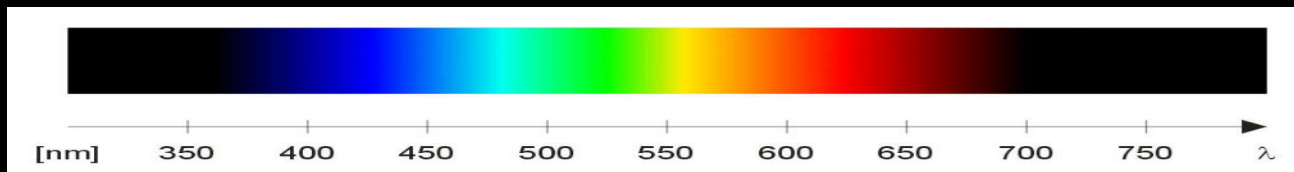


WHAT CAN WE SEE IN UV-VIS-IR?

Ultraviolet light
on sunscreen

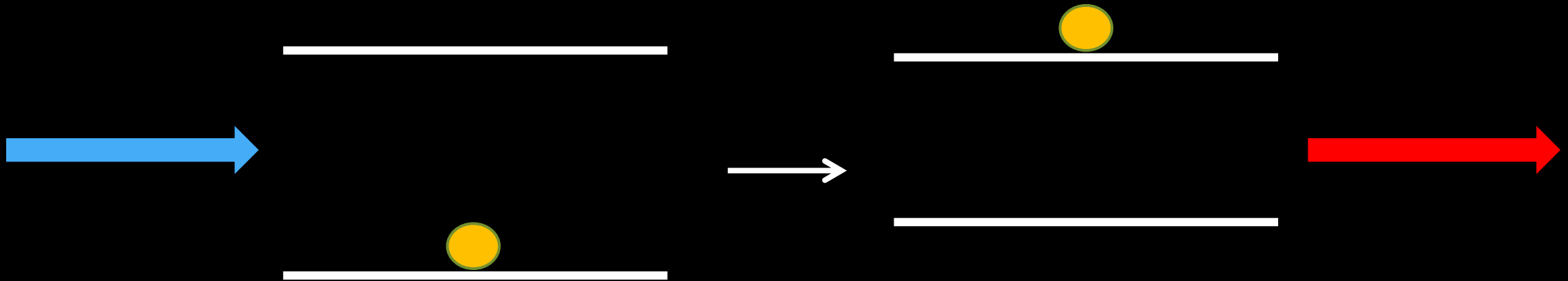


—

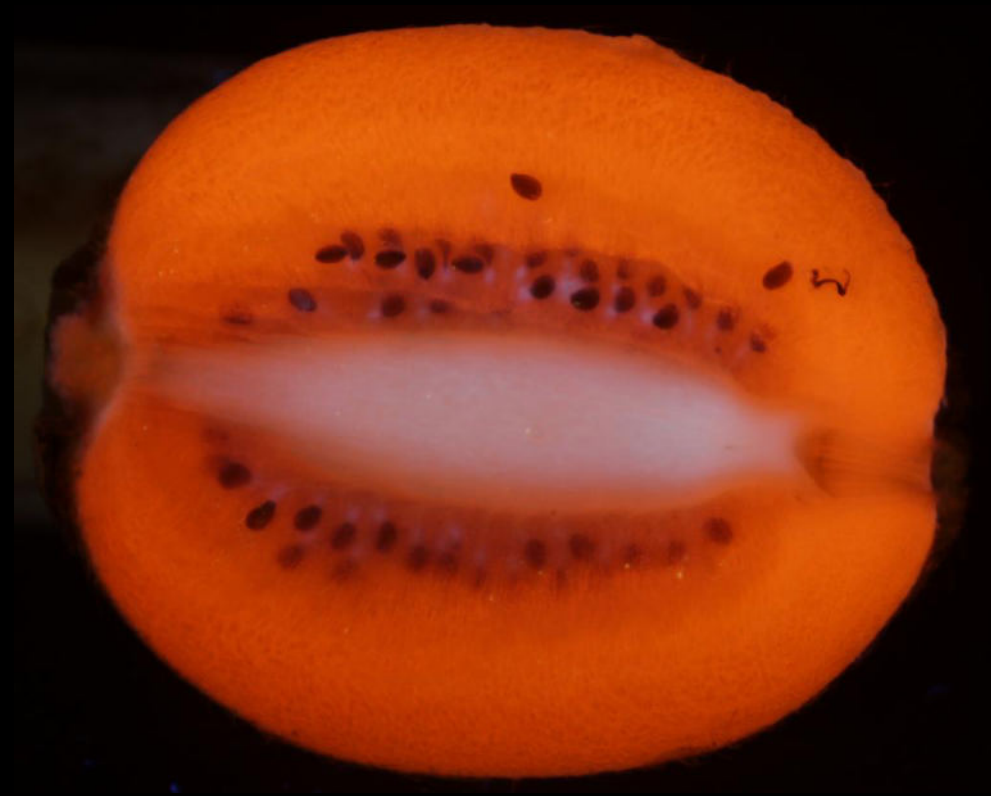


LUMINESCENCE

- An absorption – emission mechanism for light production
- Important for multispectral imaging

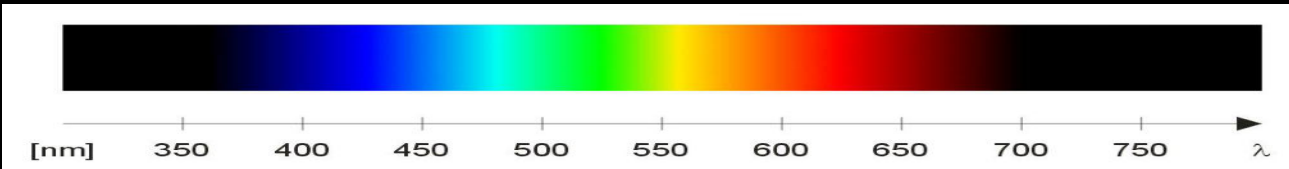


WHAT CAN WE SEE USING LUMINESCENCE IMAGING?



Shine UV
light

Record using visible light



WHAT CAN WE SEE USING LUMINESCENCE IMAGING?

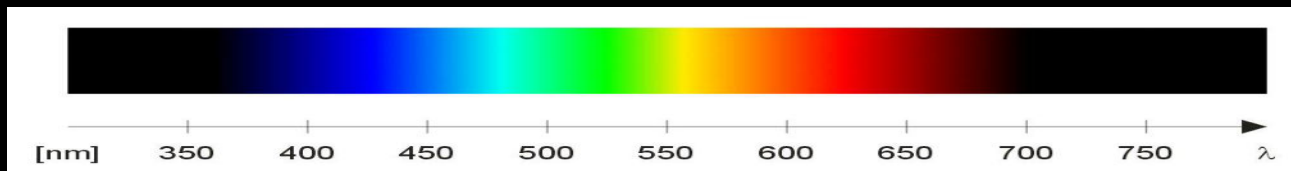


Shine UV
light

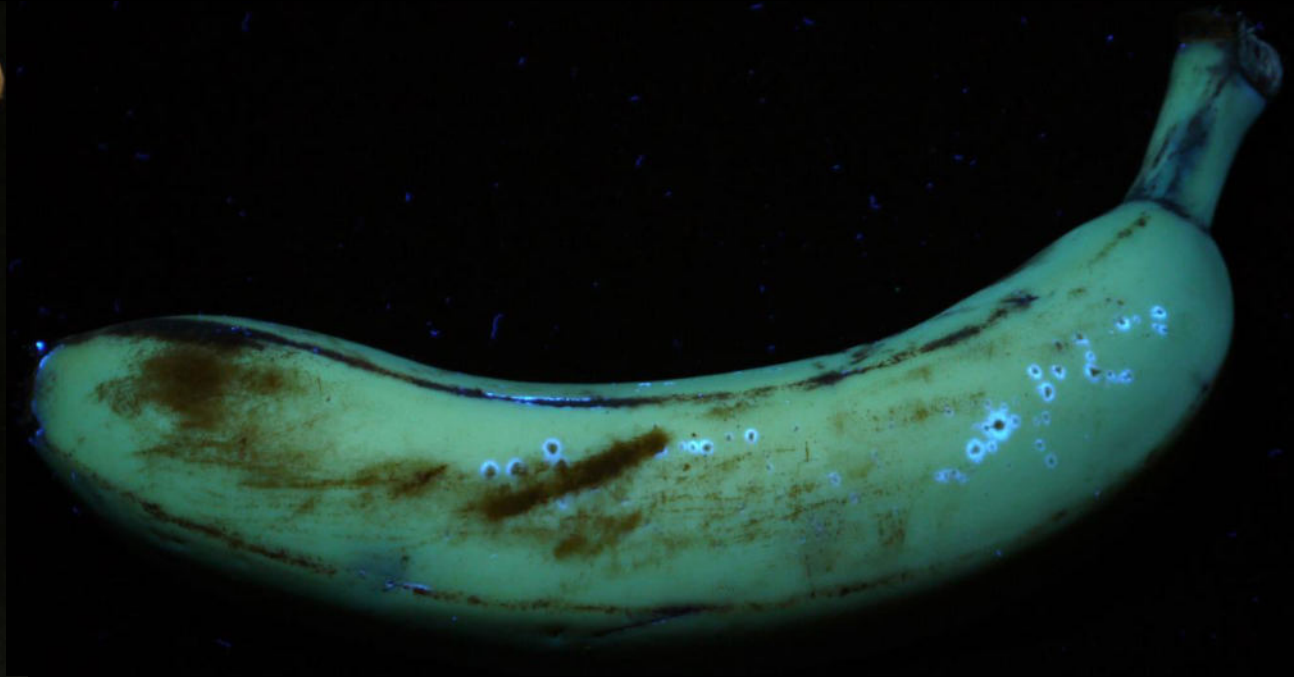
Record using visible light



Olivia's sapphire ring

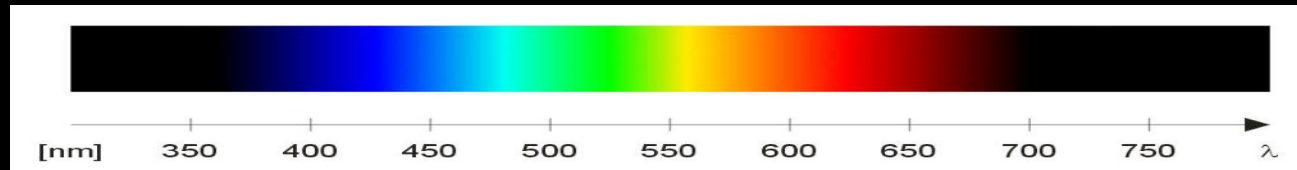


WHAT CAN WE SEE USING LUMINESCENCE IMAGING?



Shine UV
light

Record using visible light

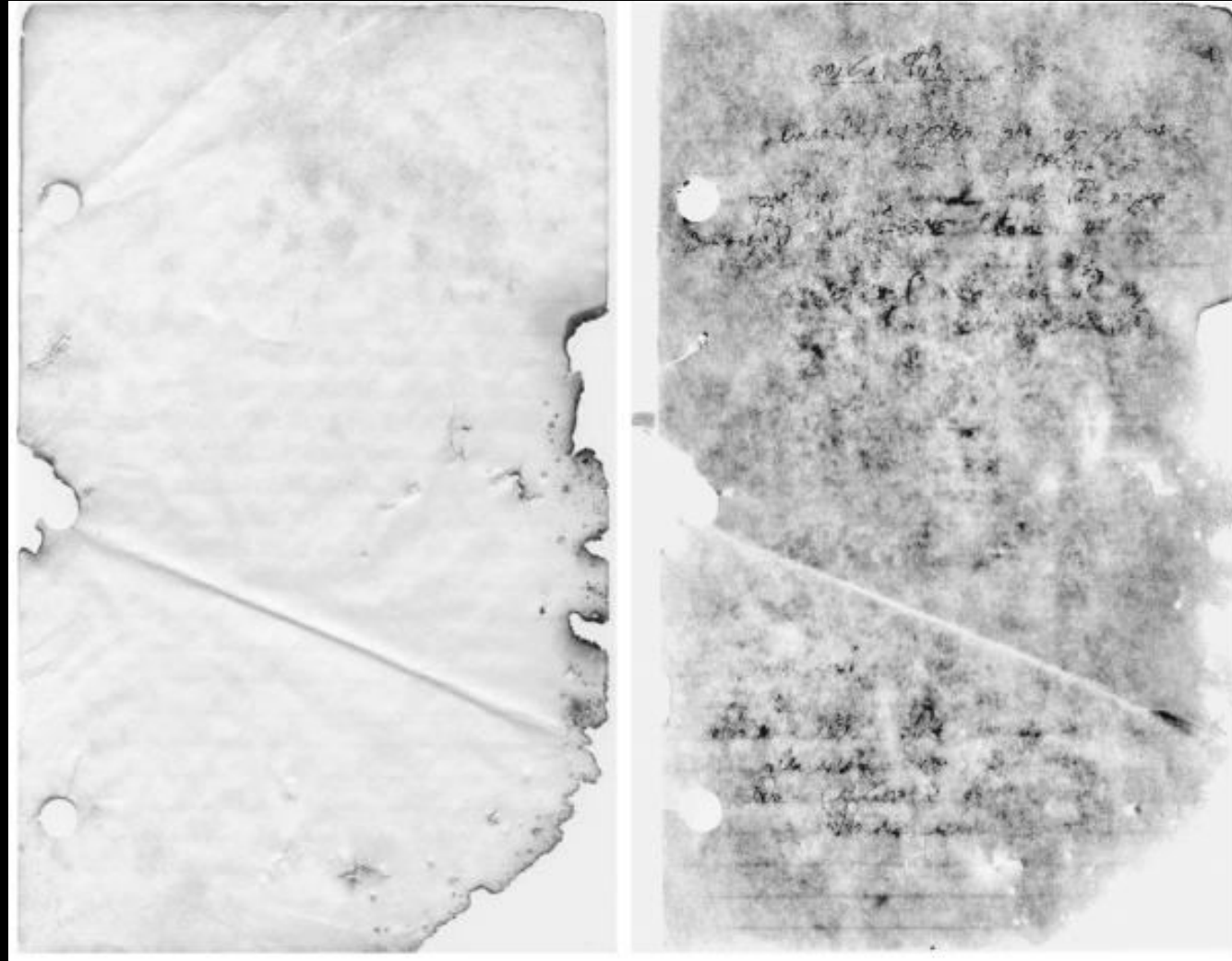


A FEW OF FAMOUS EXAMPLES

- Columbia Astronaut Diary
- Archimedes Palimpsest
- Picasso's "The Tragedy"

COLUMBIA ASTRONAUT ILAN RAMON'S DIARY

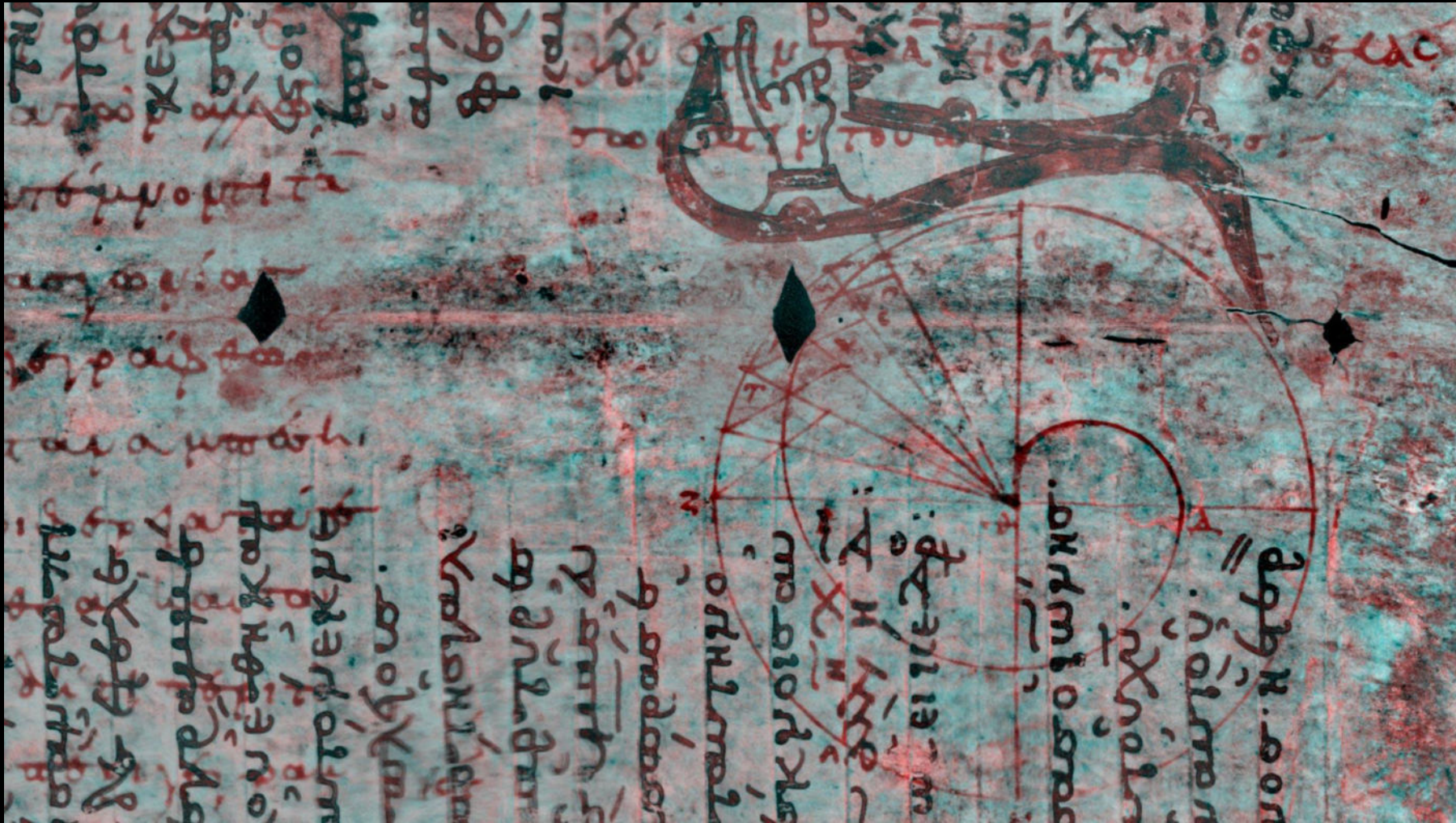
FOUND TWO MONTHS AFTER 2003 EXPLOSION



Israel Museum's Paper Conservation Laboratory – originally blue ink, imaged using infrared luminescence.

ARCHIMEDES PALIMPSEST

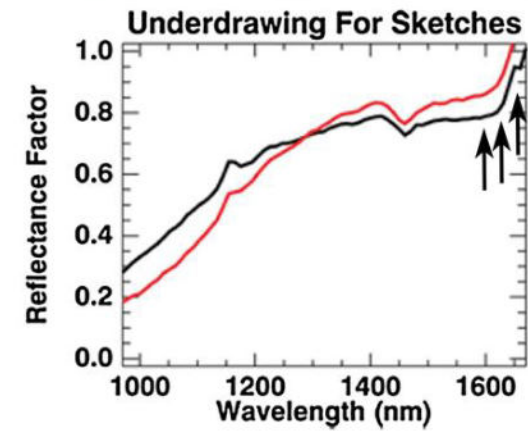
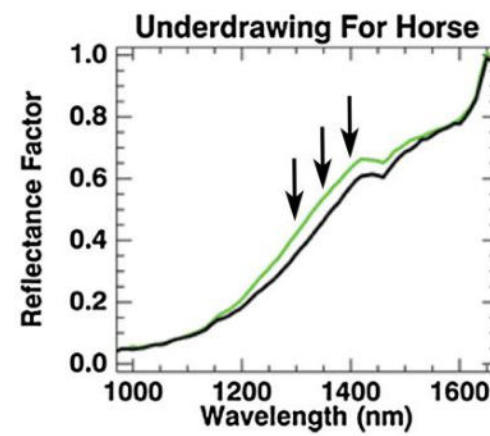
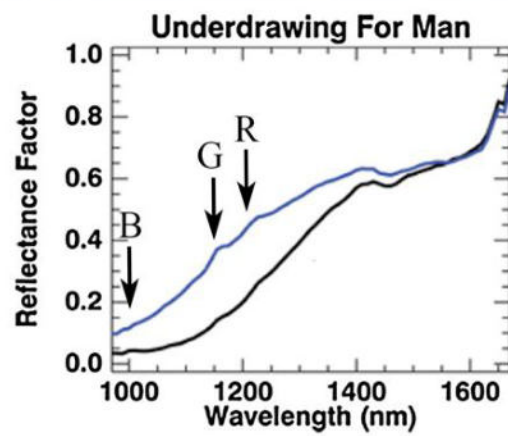
10TH CENTURY BYZANTINE GREEK COPY (HORIZONTAL LINES NOT SEEN WITH NAKED EYE)
OVERWRITTEN IN THE 13TH CENTURY WITH RELIGIOUS TEXT BY MONKS (VERTICAL LINES)



Walters Art Museum (Baltimore, USA) – multispectral imaging and an x-ray technique.

PAINTING – PICASSO'S “THE TRAGEDY”

DELANEY ET AL, HERIT SCI (2016) 4:6



ARCHIVAL IMAGING: OUR PROCESS

Condition	Camera	Illumination	Filter
Visible – White	Unmodified	White LED	No Filter
Visible – Red	Unmodified	628 nm LED	No Filter
Visible – Green	Unmodified	516 nm LED	No Filter
Visible – Blue	Unmodified	452 nm LED	No Filter
UV Luminescence	Unmodified	365 nm LED	UV blocking filter
UV Reflectance	Modified	365 nm LED	357 nm bandpass filter
IR Luminescence - Red	Modified	628 nm LED	715 nm cut-on filter
IR Luminescence – Green	Modified	516 nm LED	715 nm cut-on filter
IR Luminescence - Blue	Modified	452 nm LED	715 nm cut-on filter
IR Reflectance	Modified	880 nm LED	715 nm cut-on filter

ARCHIVAL IMAGING: OUR PROCESS

Condition	Camera	Illumination	Filter
Visible – White	Unmodified	White LED	No Filter
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IR Luminescence - Blue	Modified	452 nm LED	715 nm cut-on filter
IR Reflectance	Modified	880 nm LED	715 nm cut-on filter

SAMPLE RESULTS OF DOCUMENTS USING UV LUMINESCENCE

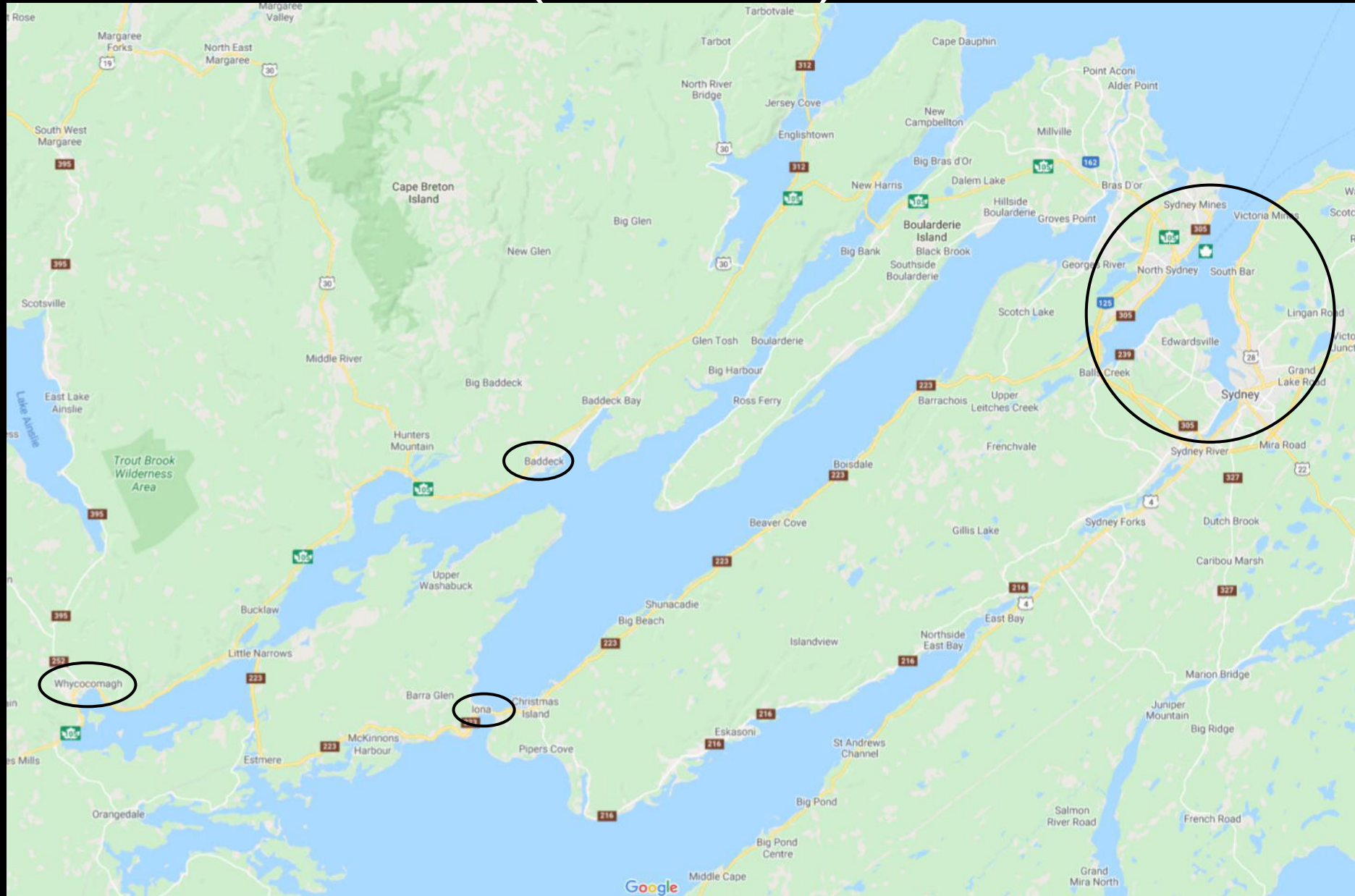
Letterbook: A book in which letters or copies of letters are kept especially to provide a running account of a business or enterprise. (Merriam-Webster dictionary)

Fonds: In archival science, a fonds is a group of documents that share the same origin and that have occurred naturally as an outgrowth of an agency, individual or organization. Examples of fonds could be the writings of a poet that were never published or a collection of correspondence between people. (Wiki)

BADDECK STEAMSHIP COMPANY LTD. (1900-1932)

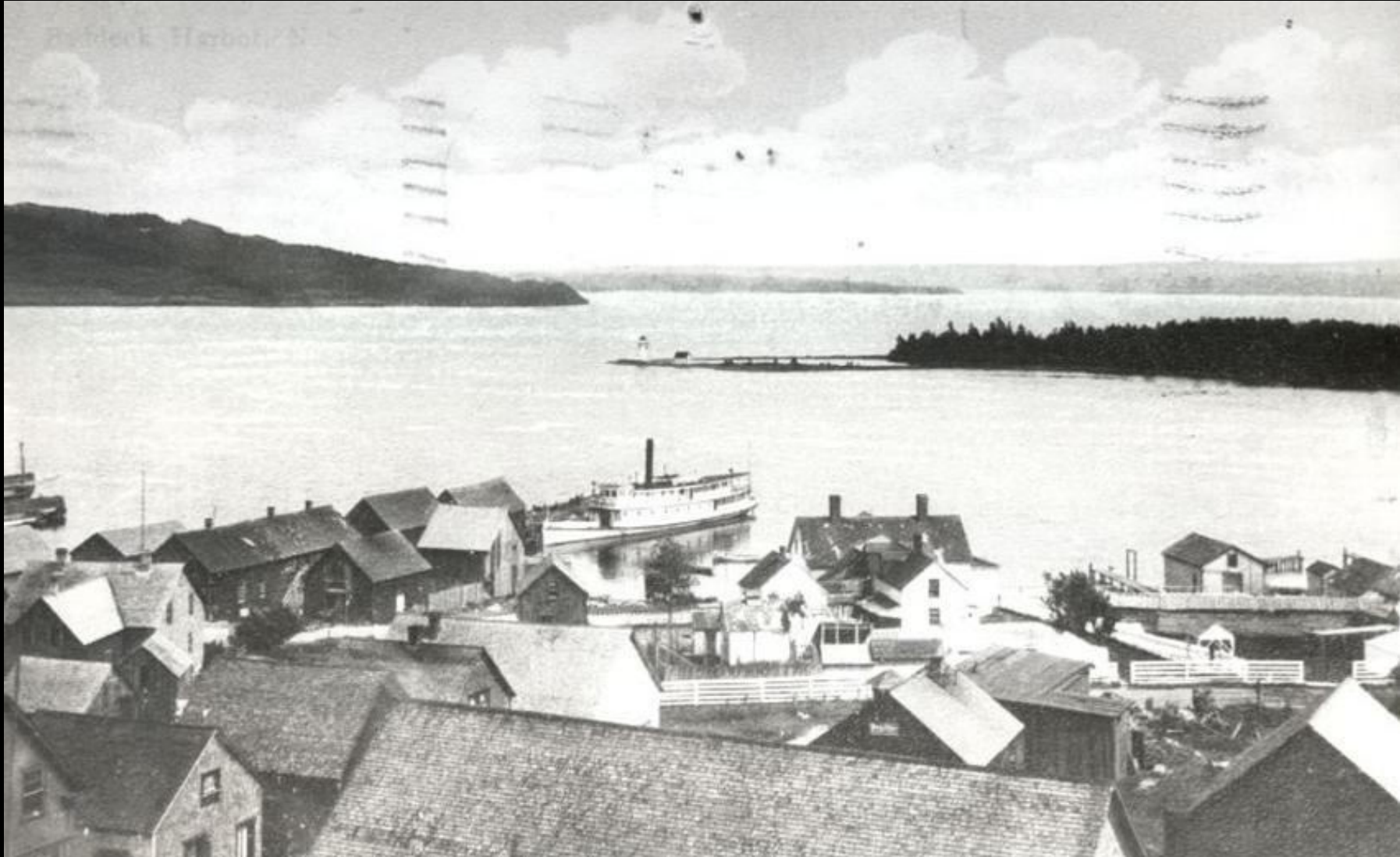
The Baddeck Steamship Company owned and operated the ferry “Marion” from the Sydneys to Baddeck, Iona, and Whycocomagh (pronounced Why-cog-ho-mah). The company bought out the Victoria Steamship Company in 1916 which operated the “Blue Hill”, a ferry running between Iona and Baddeck.

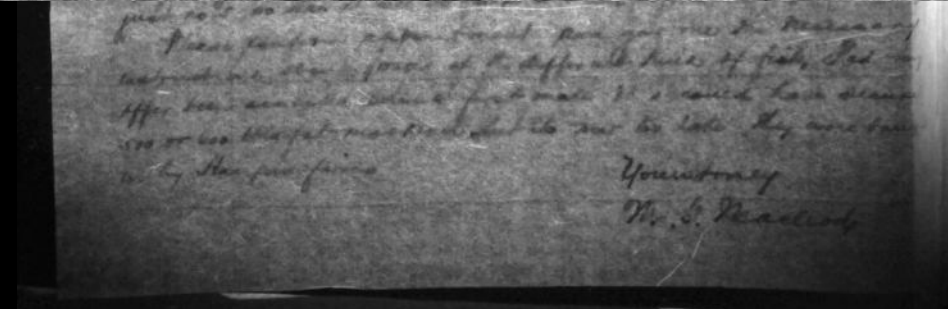
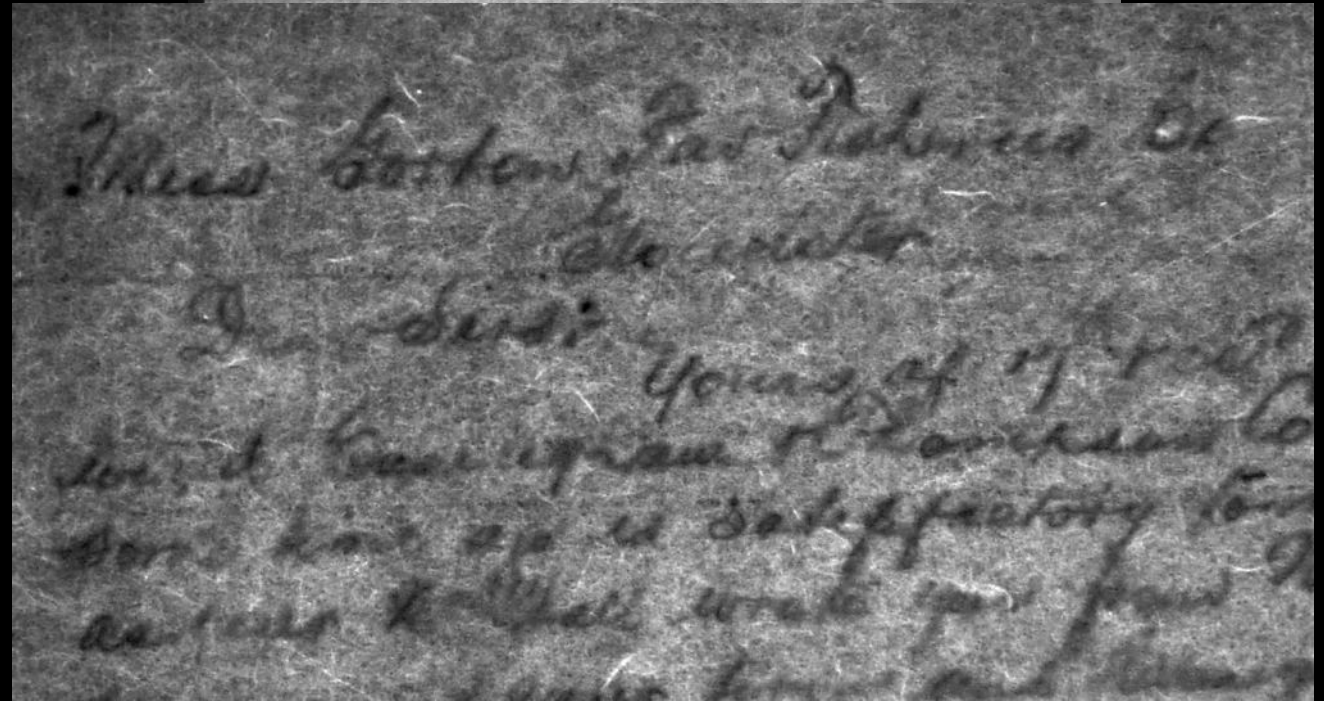
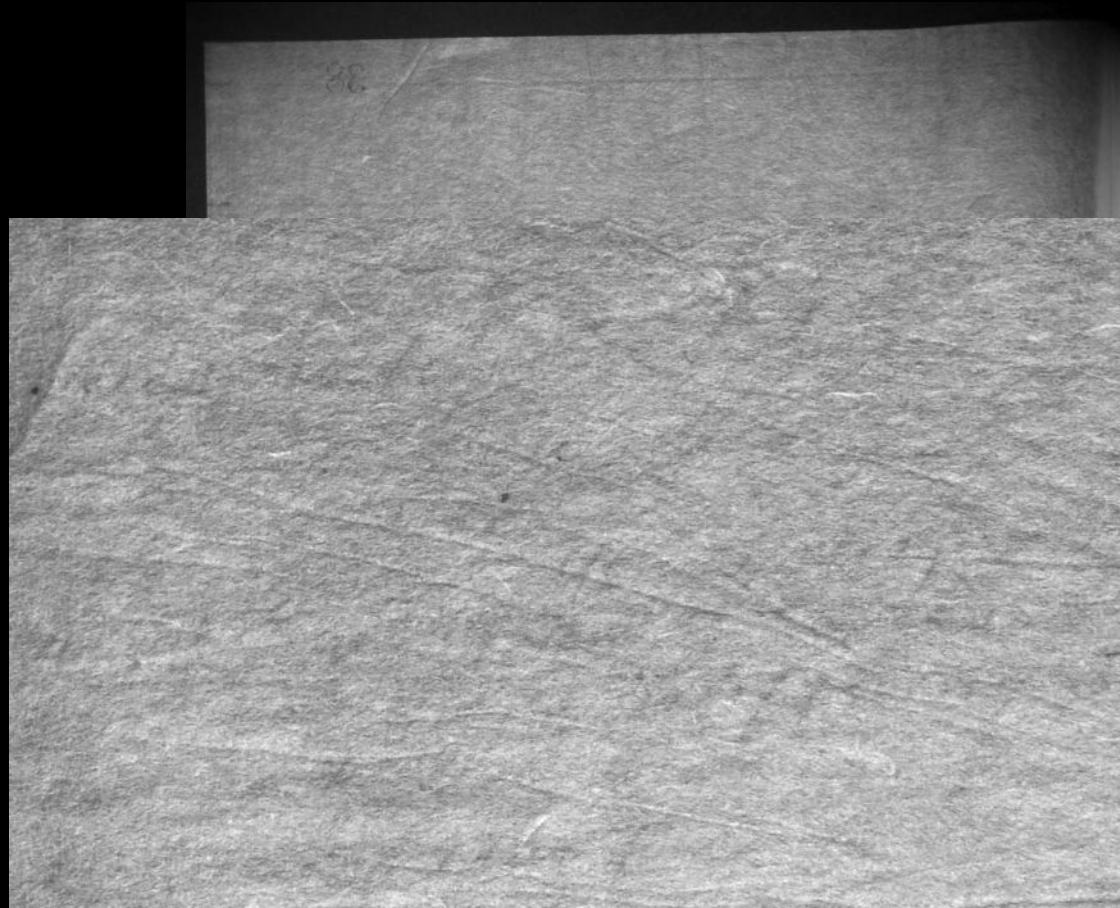
BADDECK STEAMSHIP COMPANY LTD. (1900-1932)



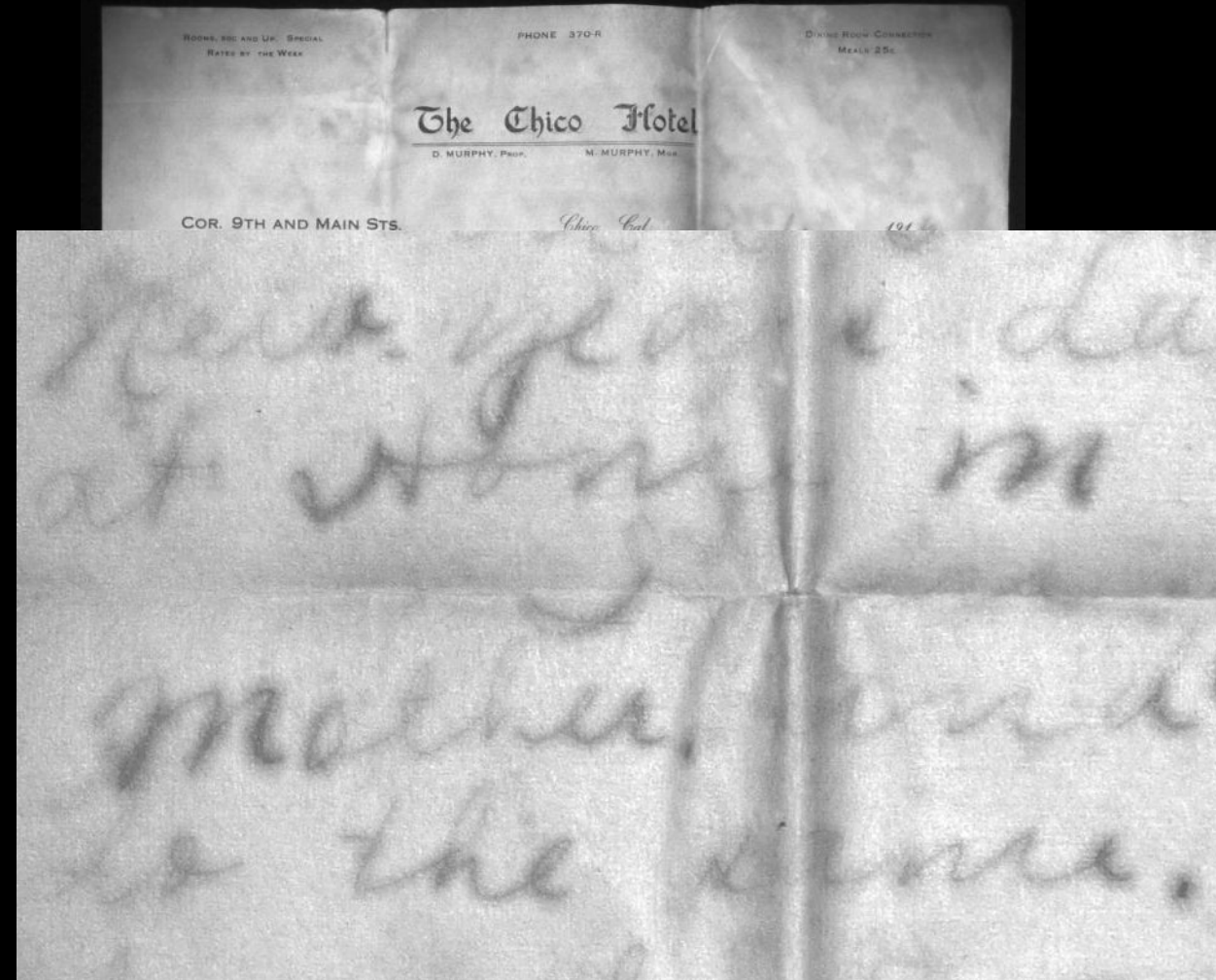
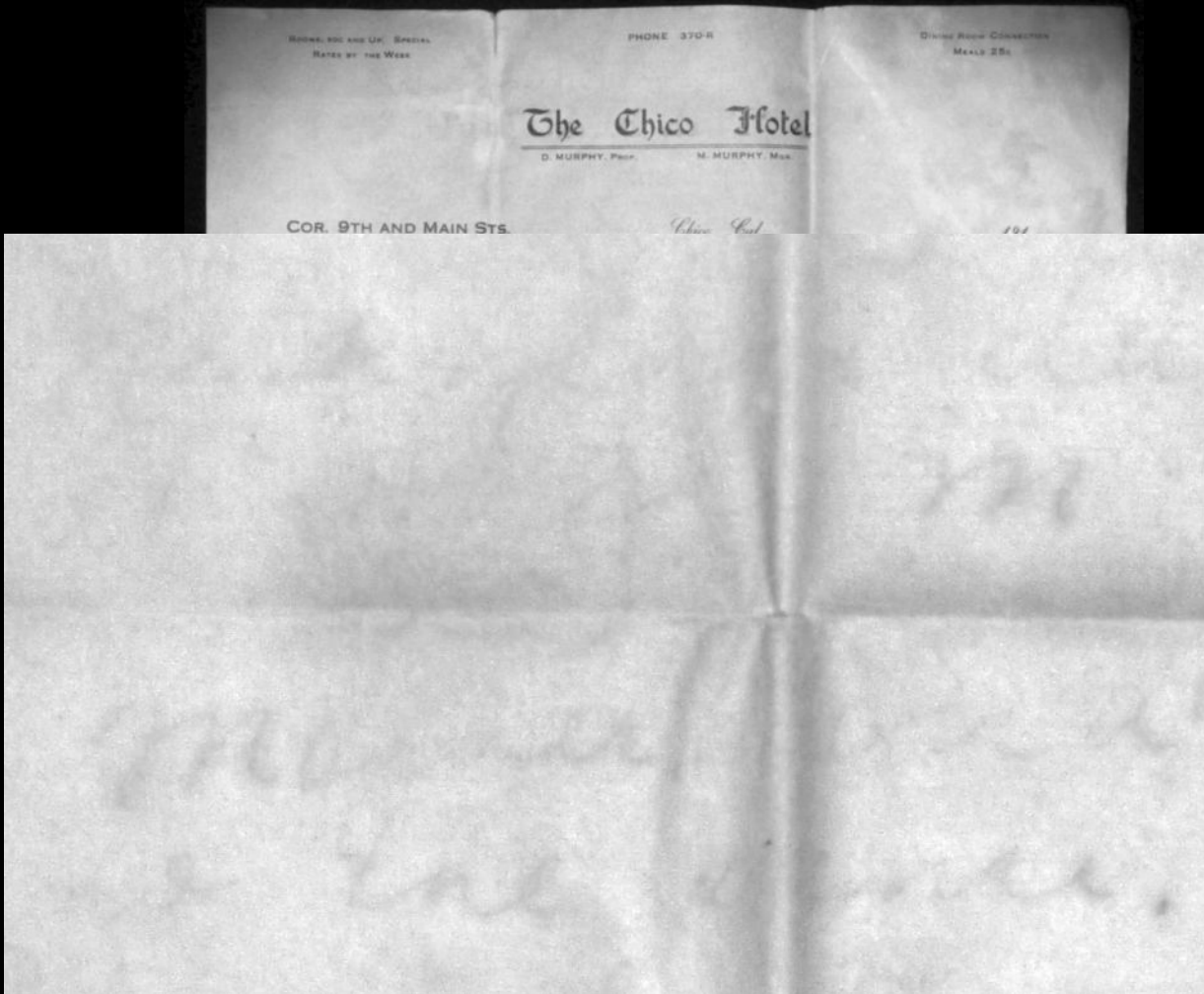
Baddeck, NS (circa 1917)

Image from the Beaton Institute Archives (77-1381-1521)



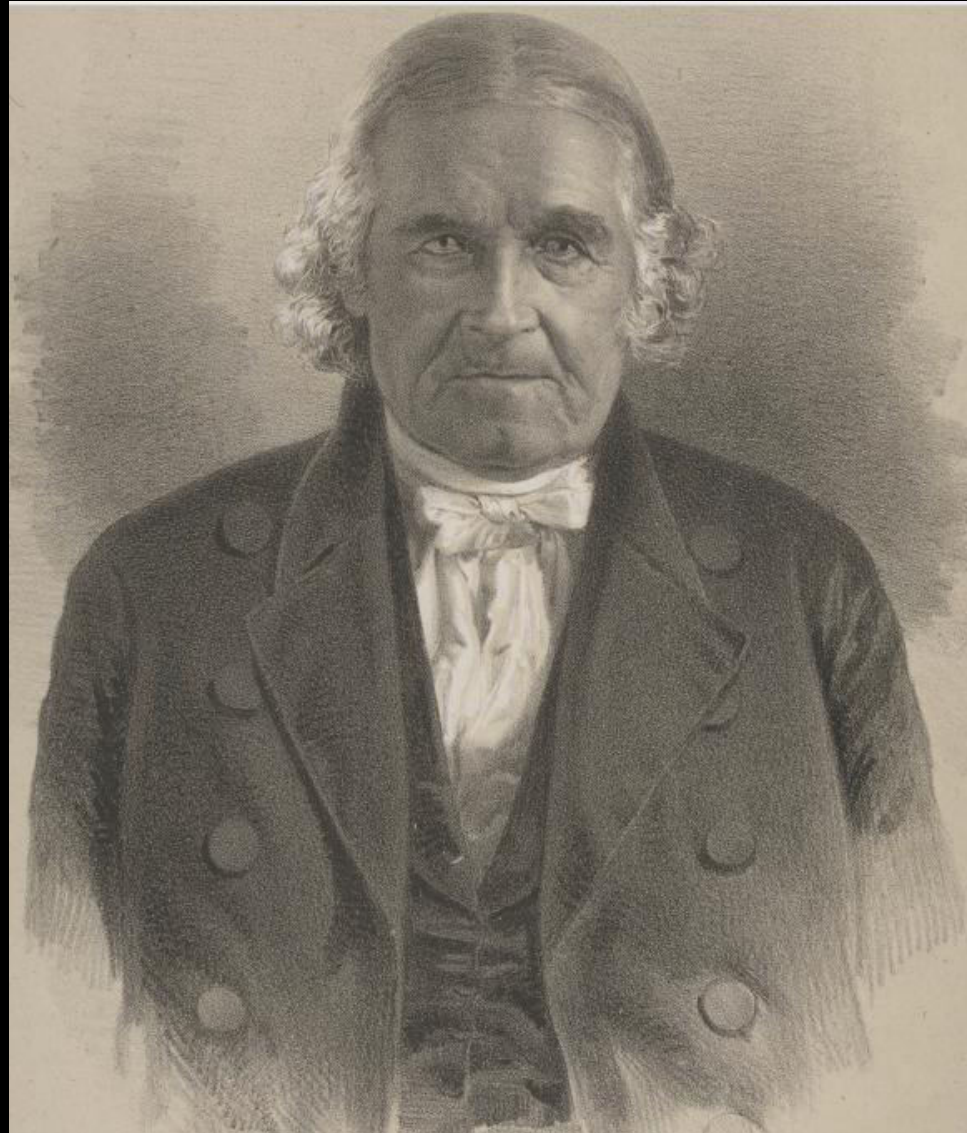


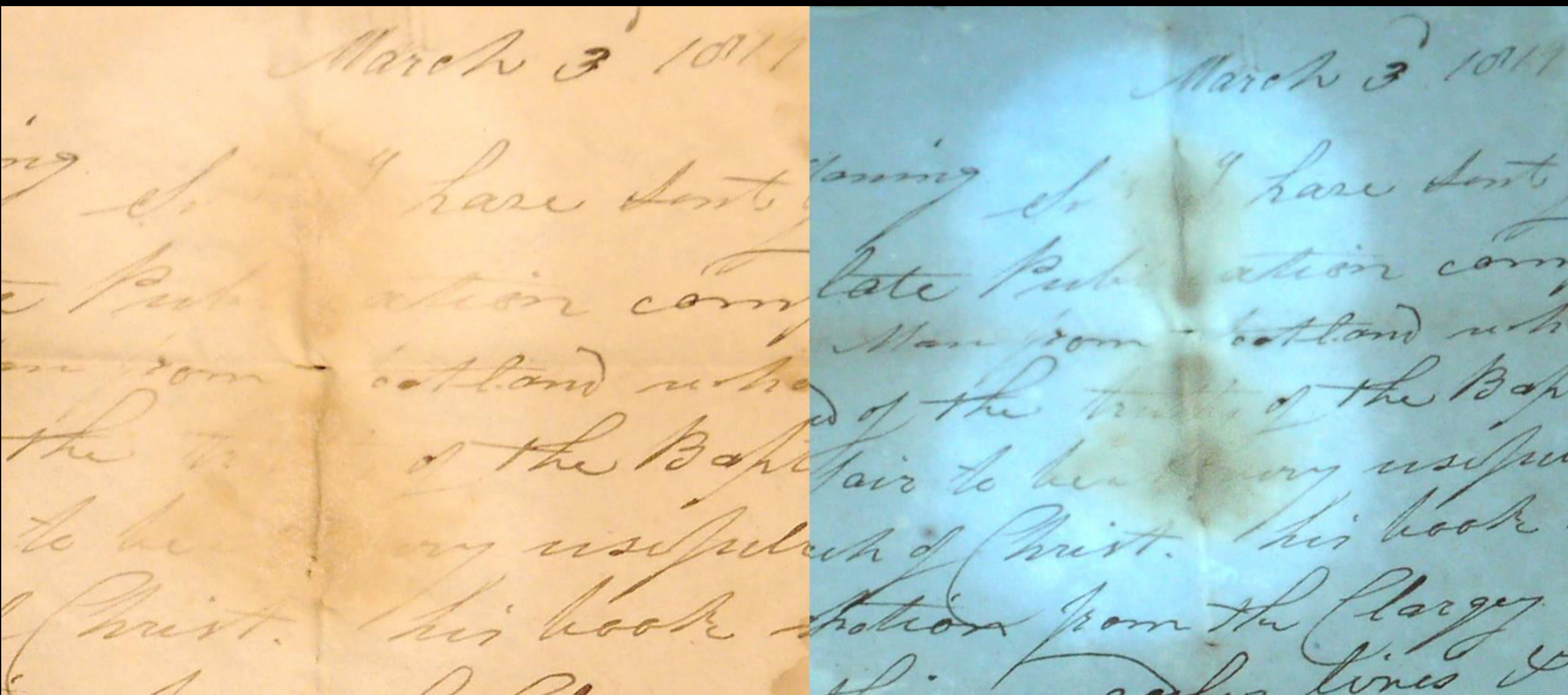
White light and UV luminescence images of
MG14_166_BaddeckSteamshipCoCorres_pg38Back



White light and UV luminescence images MG20_25_MurphyFondsCorres

EDWARD MANNING (1766-1851)
Acadia University Archives (D1846.001/8)





A composite of close-up white light and UV luminescence images of D1846 001/1/1/21. Correspondence to Edward Manning from Moses Shaw, March 3, 1819.

HAZELBROOK UNITED BAPTIST CHURCH

Acadia University Archives (D1900.039/134)



- Established December 27, 1896 in Hazelbrook, PEI
- Demolished 2007
- Some parts of the church now make up Steeple Cottage (<http://peiheritagebuildings.blogspot.com/2012/02/steeple-cottage-aka-hazel-brook-baptist.html>)



1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	22
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White light image, Hazelbrook Baptist Sabbath School Pledge

WE, the undersigned, pledge ourselves, by the assistance and help of GOD, to abstain from: I. Taking God's Name in vain; II. Tobacco in any form; III. Card Playing; IV. Intoxicating Liquors; V. Immoral Reading.

William B. Jones	1234	Orlinda Jones	1234
James B. Jones	1234	Lea Jones	1234
John B. Jones	1234	Edith Jones	1234
William Jones	1234	John Jones	1234
Carson McLeabe	12345	Clara Jones	12345
Spurgeon Jenkins	12345	Elizabeth M. Leabe	12345
Benjamin B. Jones	12345	John B. Jones	12345
William B. Jones	12345	David McVicker	1234
Arthur B. Jones	1234	William Jones	1234
Ray McLeabe	1234	Gertrude McKingie	12345
Hubert Jones	1234	Harriet Wood	1234
Samuel Jones	1234	Lucie Jenkins	1234
Harold McLeabe	1, 2, 3, 4, 5	ella Farguharson	1234
Hannie Jenkins	12345		
Victoria Jenkins	12345		

Handwritten names and numbers on lined paper, likely a pledge card. The text is faint and mostly illegible due to fading or poor reproduction quality. Visible fragments include:

- Arthur...
- 1234
- 12840
- 12345

Handwritten names and numbers on lined paper, likely a pledge card. The text is clearer than the left page. Visible entries include:

- Arthur...
- Roy McCabe 1234
- Aubrey Jones 12840
- J. Harrison Jones 12345
- Harold McCabe 1, 2, 3, 4, 5
- Fannie Jenkins 12345
- Victoria Jenkins 12345

Close up of white light and UV luminescence images, Hazelbrook Baptist Sabbath School Pledge.

POTENTIAL MATERIALS & MECHANISM: DARK INK

- Iron gall ink (these examples only)
 - Handwritten documents
 - At its simplest, made of iron sulfate, tannins, and binders
 - Fades due to a variety of factors – acid hydrolysis, sensitive to light (Reissland and Cowan, 2014)
 - Been ‘restored’ using UV fluorescence photography since 1914 (Knight, 2014)
 - Paper luminesces around traces of ink, which remains dark.
- Carbon black-based ink
 - Used in carbon copy paper
 - Has fine, amorphous carbon black as a pigment (How It’s Made)
 - Mechanism very similar to that of iron gall

SAMPLE RESULTS OF DOCUMENTS USING NEAR INFRARED LUMINESCENCE

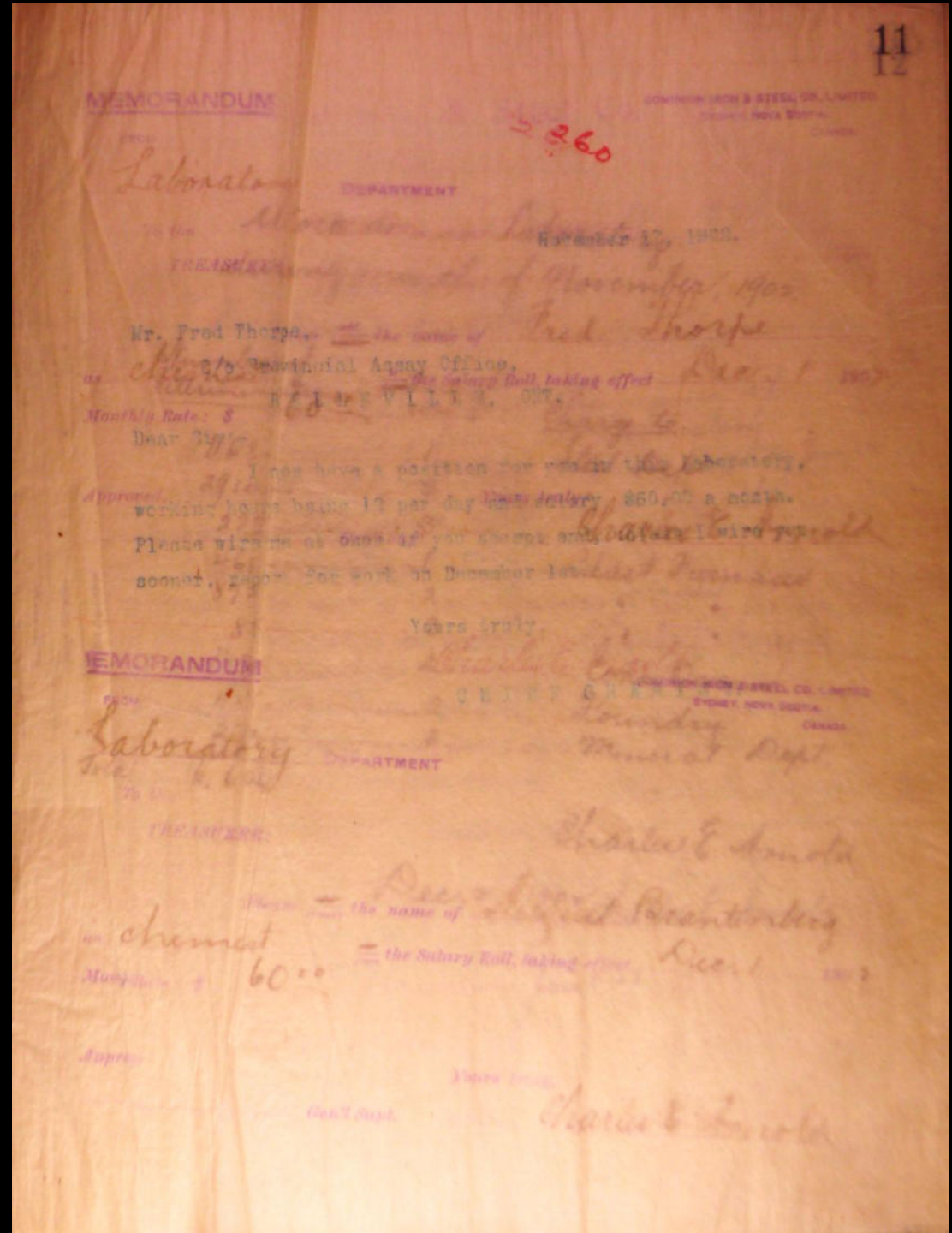
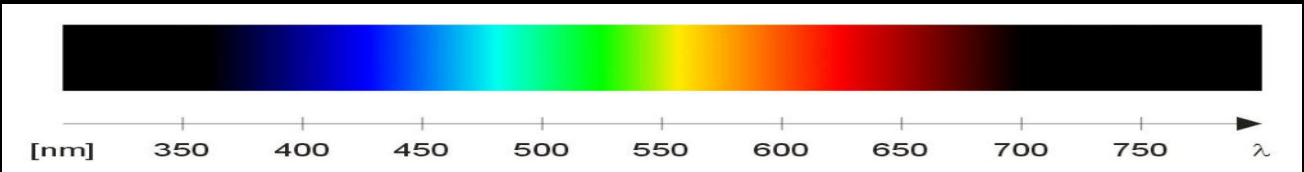
DOMINION IRON AND STEEL CO., SYDNEY, NS

BEATON INSTITUTE ARCHIVES 7-620-754



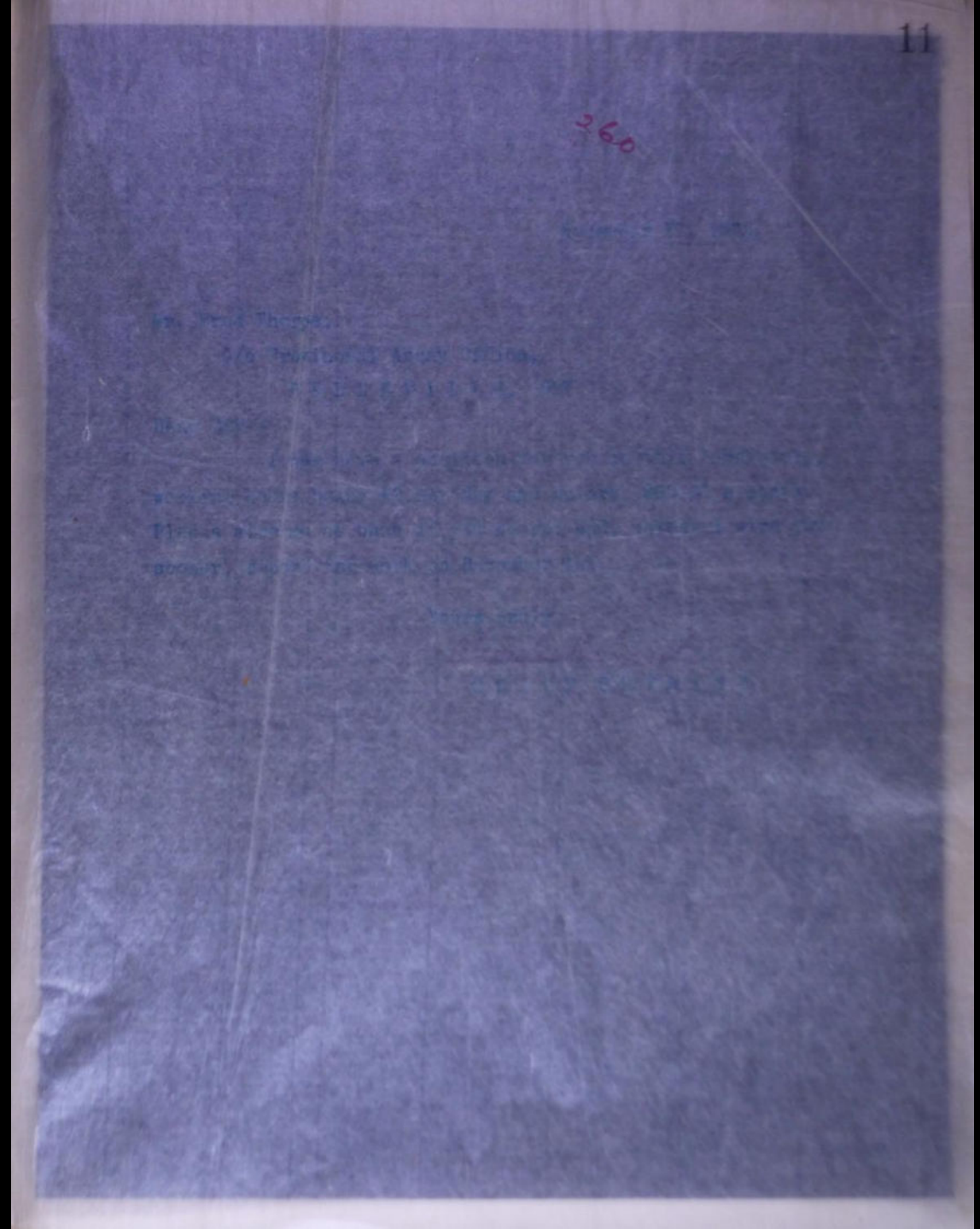
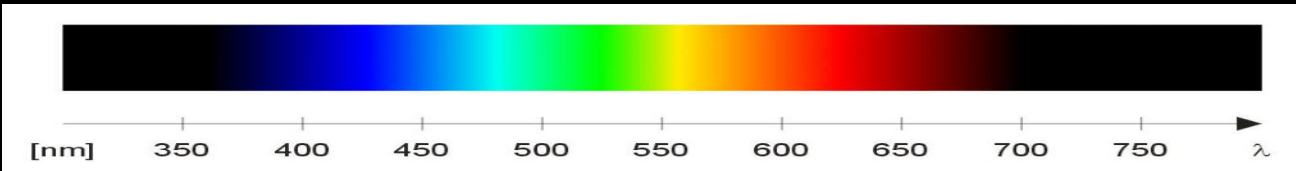
DOMINION IRON AND STEEL CO. LETTERBOOK (MG14.38 PAGE 11, NOV. 17, 1902)

White LED light image of page as it
appears in the letterbook.



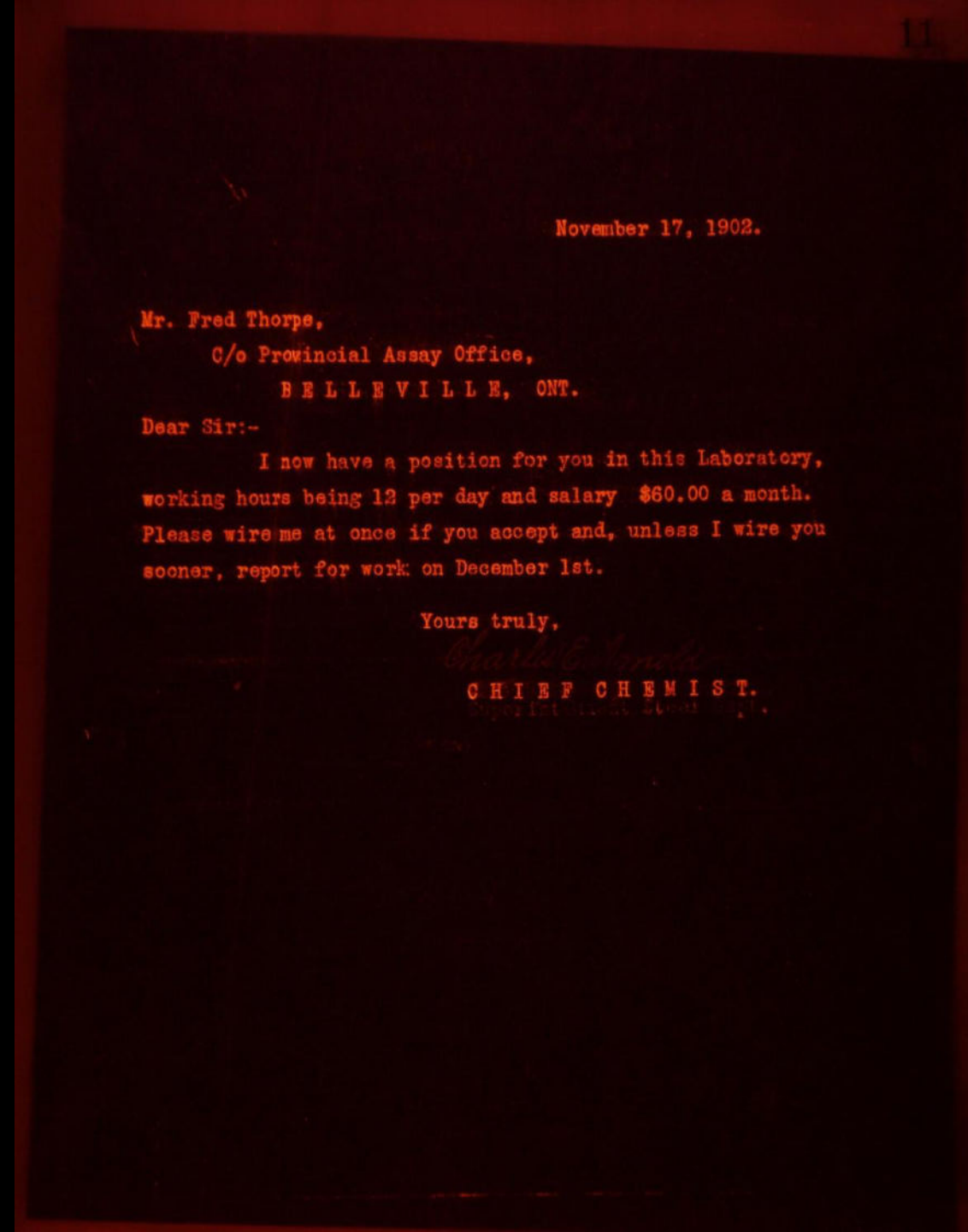
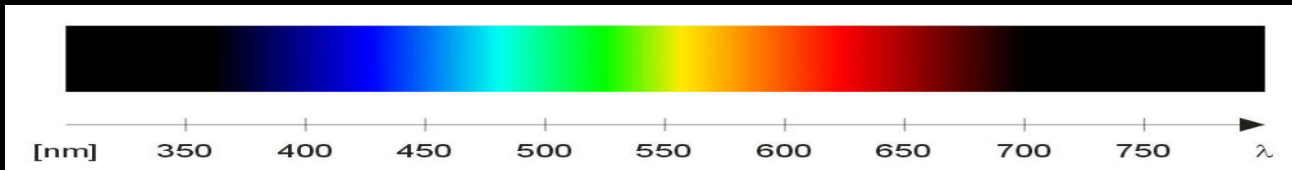
DOMINION IRON AND STEEL CO. LETTERBOOK (MG14.38 PAGE 11, NOV. 17, 1902)

White LED light image of page
with a black, light-absorbing sheet
behind the page to block bleed-
through from underlying pages.



DOMINION IRON AND STEEL CO. LETTERBOOK (MG14.38 PAGE 11, NOV. 17, 1902)

Red LED light was shone on the
page and luminescence in the near-
IR was used to record the image.



November 17, 1902.

Mr. Fred Thorpe,

C/o Provincial Assay Office,

BELLEVILLE, ONT.

Dear Sir:-

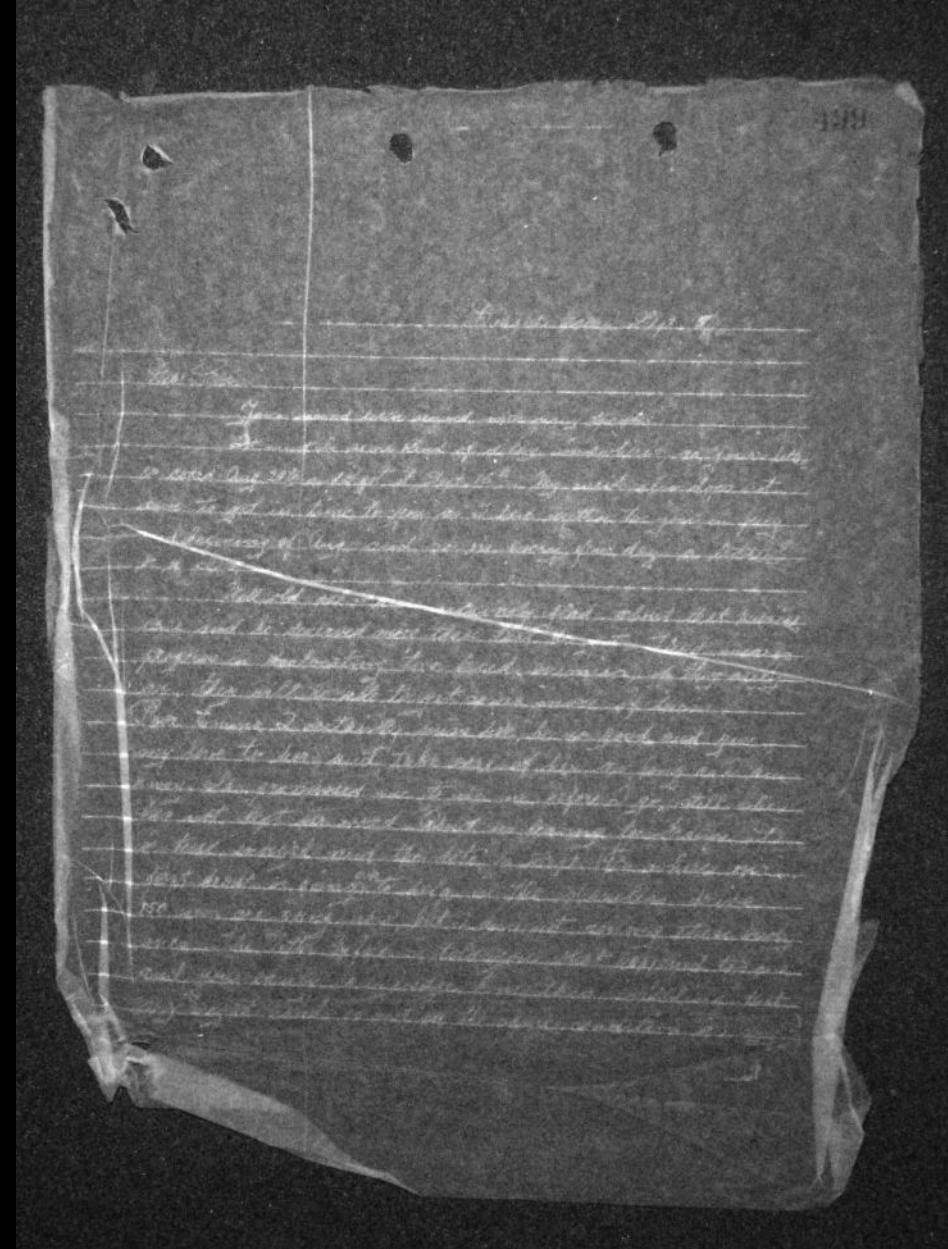
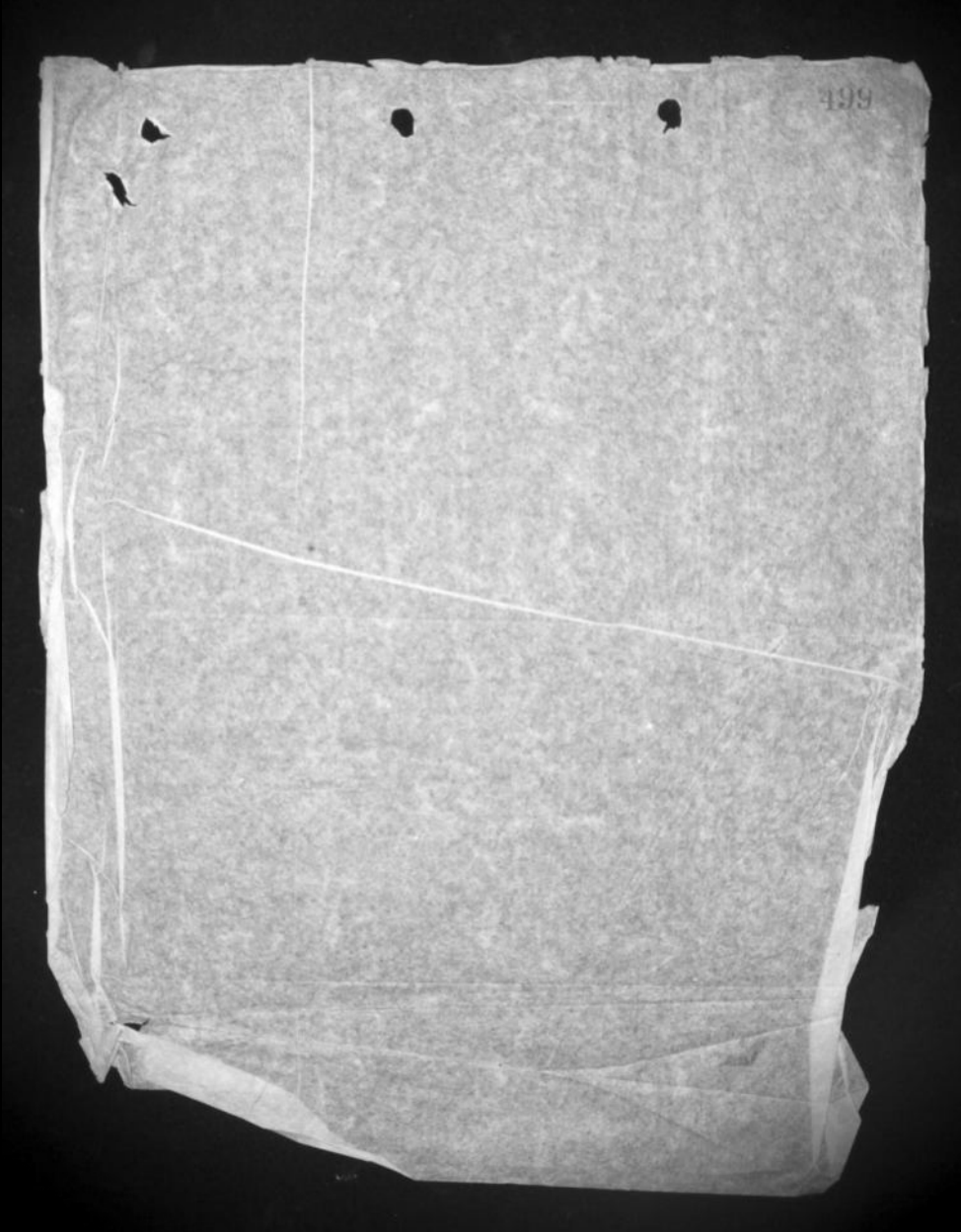
I now have a position for you in this Laboratory,
working hours being 12 per day and salary \$60.00 a month.
Please wire me at once if you accept and, unless I wire you
sooner, report for work on December 1st.

Yours truly,

Charles E. Arnold

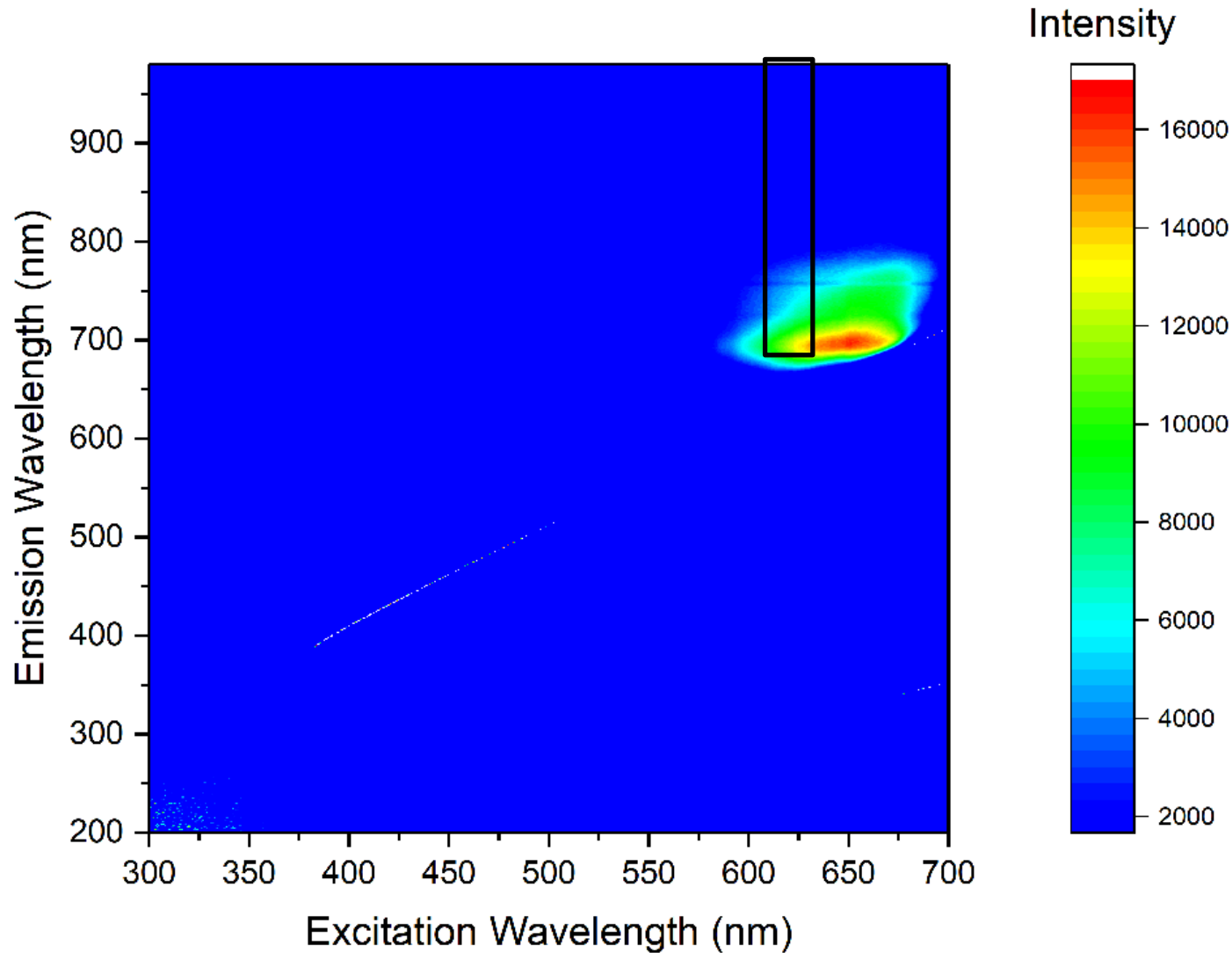
CHIEF CHEMIST.

Superintendent Steel Dept.



White light and IR luminescence images of a letter from the Robert Hubley Fonds.

LUMINESCENCE: BLUE INK



Excitation spectroscopy map of a blue ink sample from the MG 14.38-2 Dominion Iron and Steel letterbook.

POTENTIAL MATERIALS & MECHANISMS: BLUE INK

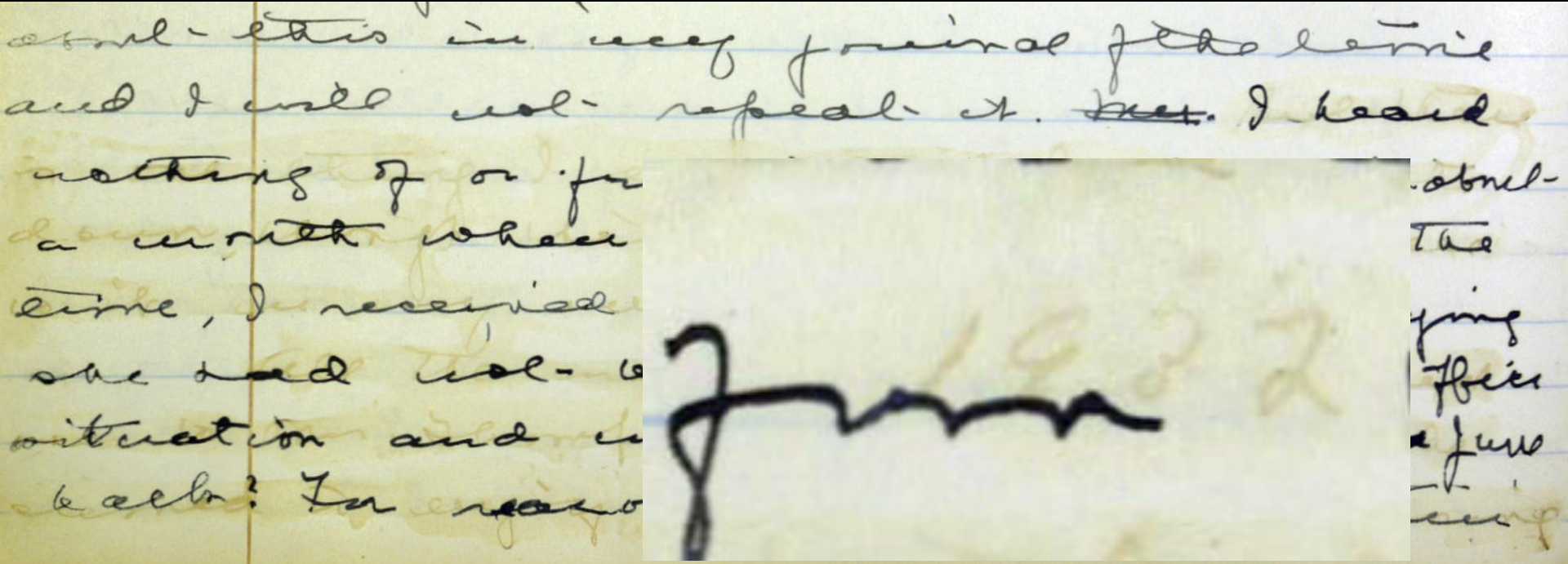
- Pigment is likely Prussian blue (PB)
 - Hydrated iron(III) hexacyanoferrate(II)
 - Light absorption given by homonuclear intervalence charge transfer between the Fe^{3+} and Fe^{2+} atoms
- A relatively cheap, readily available blue pigment in the late 1800's - early 1900s
- Was used in typewriter carbon paper and stamp inks
- Fades in anoxic (low oxygen) environments often used for preservation (Gervais et al, 2014; Rowe, 2004)
- Sensitive to light when mixed with white pigments (Samain et al, 2011)
- Impurities affect the aging process (Martinetto and Bardet, 2013)

A CHALLENGE FROM L.M. MONTGOMERY'S JOURNALS

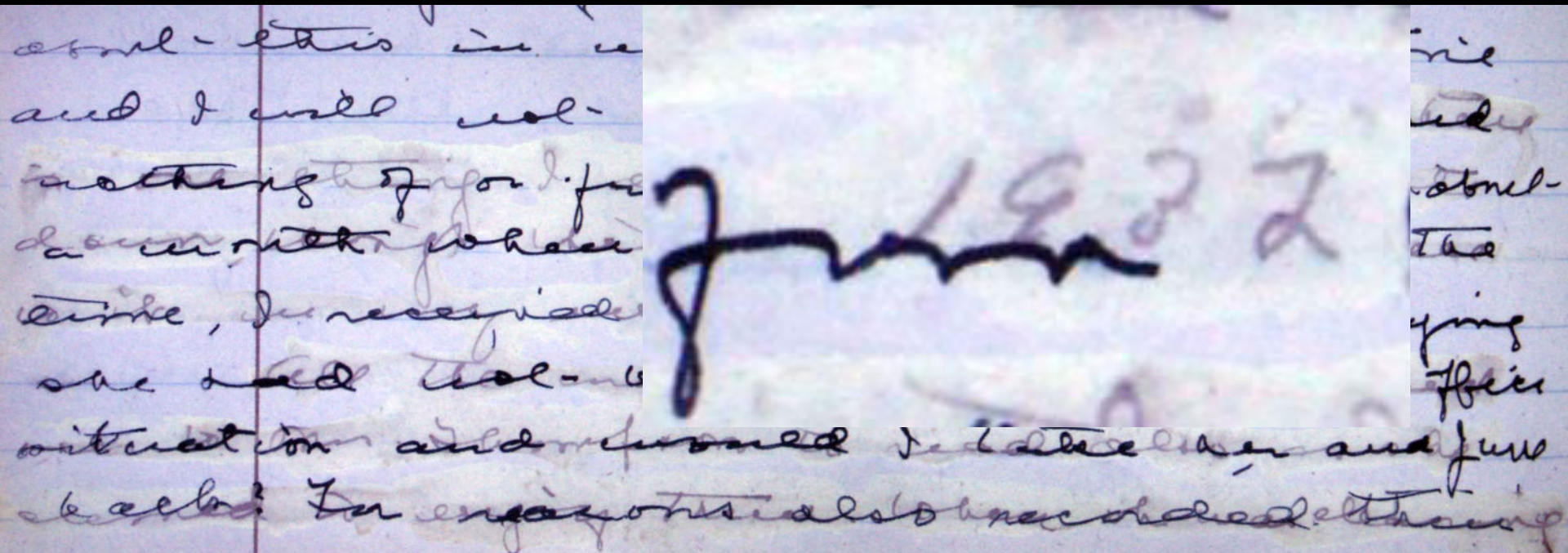
140

the shadow of his malady; but - I am glad
I have made him happy, at least - for that
at least, I have not failed in anything
thing, as in my discouraged mood
I am sometimes inclined to think I have.
I finished a short story to-day
- "The Lullaby of the White Lady" - a fairly
little thing.

Have been very busy these past
weeks - but - where ever I find - busy? And
I should be - and am - very thankful
that I can be busy - that I can plan
and execute and undertake things. Only
at night - I am just a little too tired.
Late in copying and done



White
Light

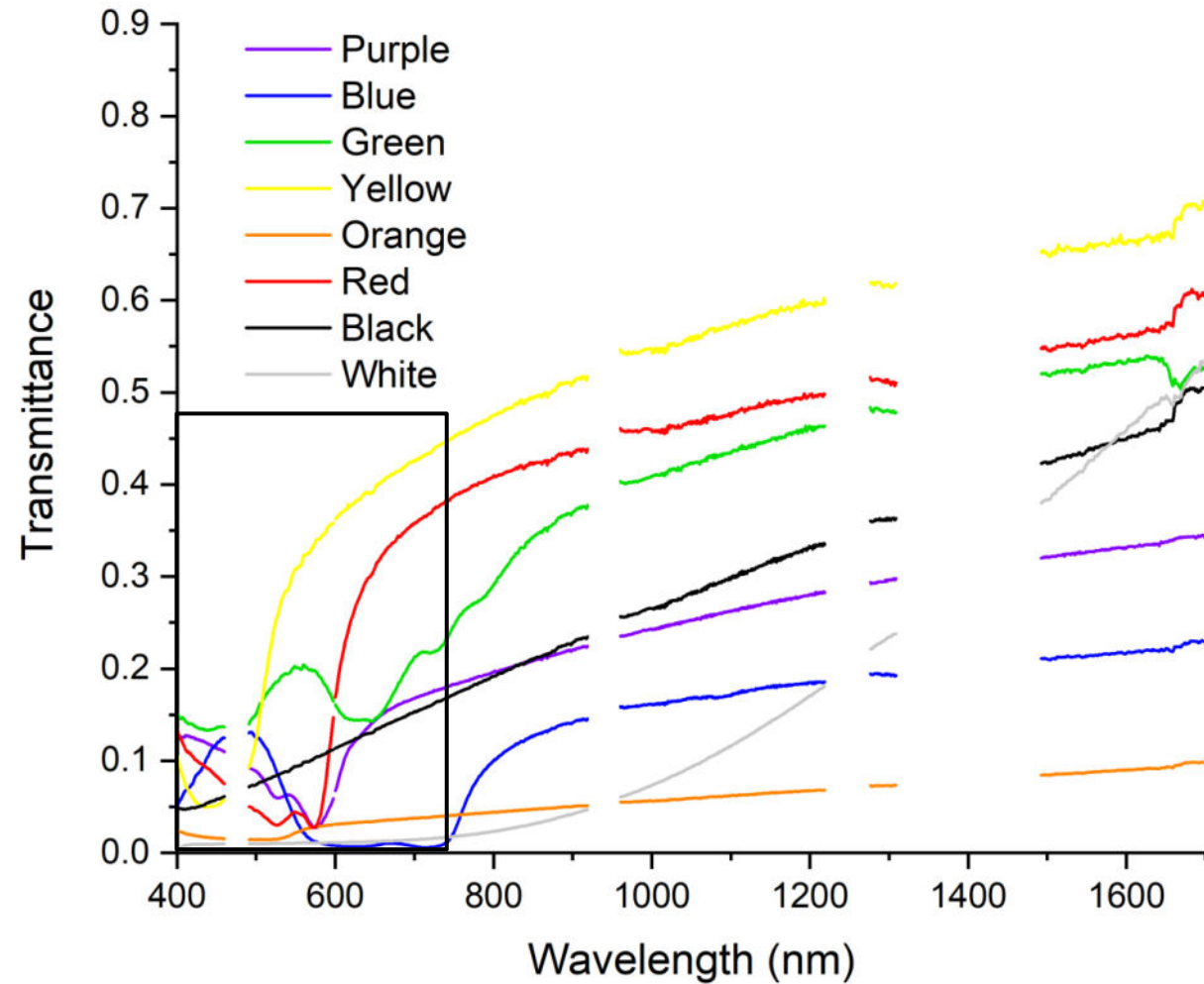


UV
Luminescence

SAMPLE RESULTS FROM PAINTINGS

- Paintings from the Sinclair Inn in Annapolis Royal, NS and Barbara Martin, a local Wolfville artist.

LIGHT TRANSMISSION OF PAINT



LIGHT TRANSMISSION OF PAINT

ORIGINAL PENCIL DRAWING (BARB MARTIN)



LIGHT TRANSMISSION OF PAINT OVER-PAINTING, WHITE LIGHT, NORMAL CAMERA



LIGHT TRANSMISSION OF PAINT

880 NM LIGHT, UV-IR CAMERA



LIGHT TRANSMISSION OF PAINT

1550 NM LIGHT, SCANNING IMAGE



LIGHT TRANSMISSION OF PAINT



SINCLAIR INN, ANNAPOLIS ROYAL

[HTTP://ANNAPOLISHERITAGESOCIETY.COM/SINCLAIR-INN-MUSEUM/](http://annapolisheritagesociety.com/sinclair-inn-museum/)



SINCLAIR INN, ANNAPOLIS ROYAL

[HTTPS://ANNAPOLISROYAL.COM/ATTRACTIONS-AND-MUSEUMS/SINCLAIR-INN-NATIONAL-HISTORIC-SITE/](https://annapolisroyal.com/attractions-and-museums/sinclair-inn-national-historic-site/)

- Parts of the structure were built in 1710 and is the oldest surviving example of Acadian construction techniques open to the public.
- In 1738, the building was used by Erasmus Phillips as the first meeting hall of the Masonic Lodge in Canada.
- The second floor includes the restored 'Painted Room' created in c. 1840.

SINCLAIR INN, ANNAPOLIS ROYAL

[HTTP://HALIFAXLED.COM/2019/04/10/SINCLAIR-INN-MUSEUM/](http://halifaxled.com/2019/04/10/sinclair-inn-museum/)

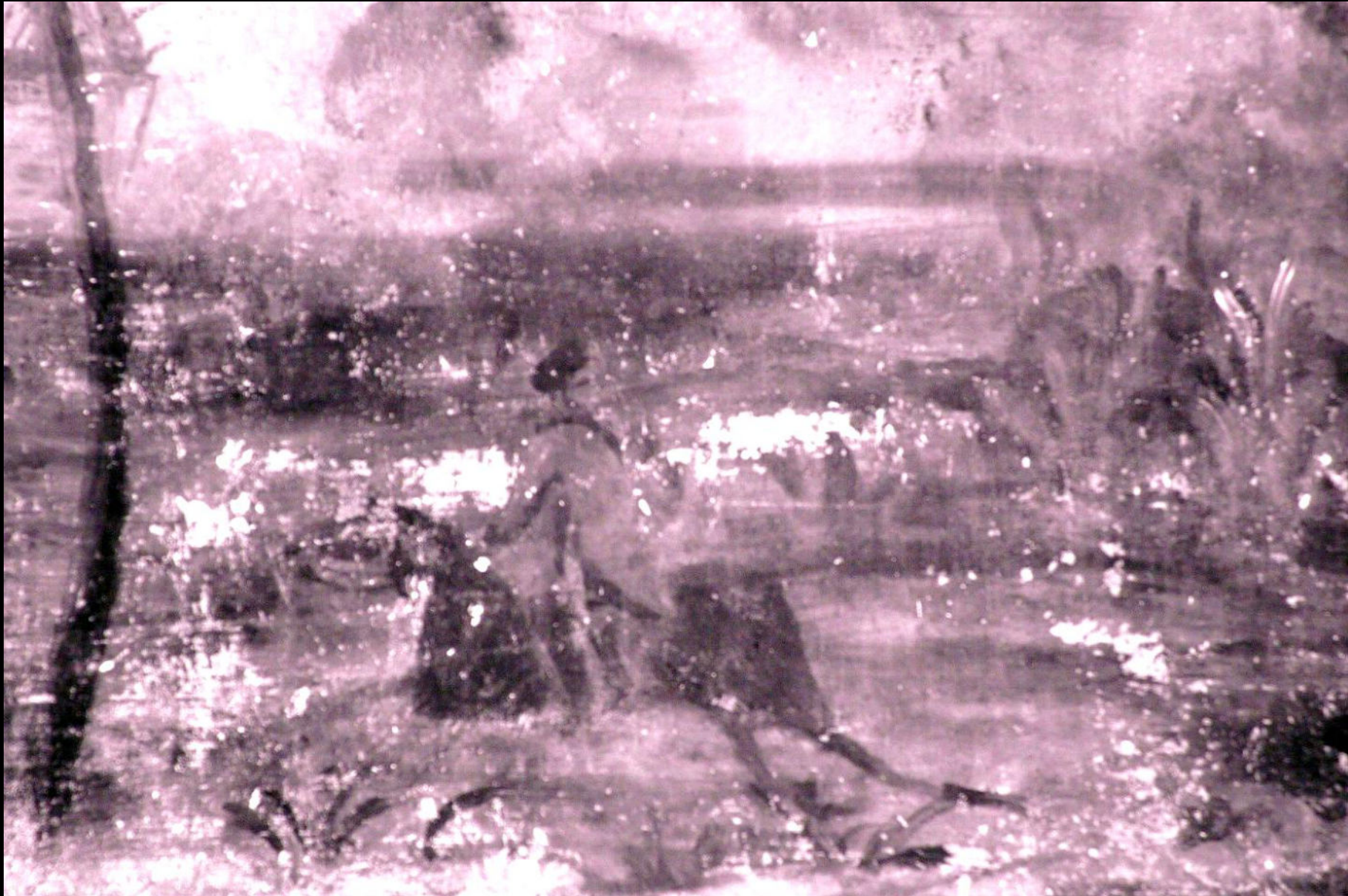


PAINTING – SINCLAIR INN, ANNAPOLIS ROYAL
MUSEUM LIGHTING, NORMAL CAMERA



PAINTING – SINCLAIR INN, ANNAPOLIS ROYAL

880 NM LIGHTING, UV-IR CAMERA



IN SUMMARY

- By using a variety of optical and other scientific techniques contrast can be restored in documents and paintings (in many cases).
- The mechanisms of degradation of the ink can be determined, or at least hypothesized.
- Scratching the surface of some the history and background of these works is incredibly fascinating as well as addicting. I may need a support group so that I can get on with some other areas of life.

ACKNOWLEDGEMENTS



- Jane Arnold of the Beaton Institute, CBU
- Catherine Fancy and Wendy Robicheau of the Acadia Esther Clark Wright Archives
 - Sinclair Inn, Annapolis Royal, NS
 - Barbara Martin, Wolfville, NS

Thank you!

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