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RE-ENCHANTED IMAGES

Natural Pigments in Photographic Practices

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Keywords

pigment extraction; naturally derived pigments; alternative photographic processes; alt photography; disenchantment; artisan crafts; anthotype; cyanotype

Klíčová slova

extrakce pigmentu; přirozeně odvozené pigmenty; alternativní fotografické postupy; alternativní fotografie; odkouzlení; umělecká řemesla; antotypie; kyanotypie

Abstract

The focus of this thesis lies on the combination of practices connected to colour extraction as well as alternative photographic processes; these two historically and artistically important crafts have strongly influenced each other throughout the course of history. The combination of both is a very particular phenomenon, and poses questions related to lightfastness, fixation, application processes, and photosensitive reactions, all of which have a long history in both photography and dyeing as well as pigment extraction.

While focusing on the photographic applications of natural pigments, historical developments of the same (to include various methods of combination pioneered and utilised by artists and scientists), this thesis will also provide an overview of the chemical and molecular properties of various natural and artificial pigments. The subjects discussed will illustrate the connection between ancient techniques of colour extraction and more recent photographic processes innovated and developed in the nineteenth century, both of which are currently experiencing a popular resurgence on a global scale.

Additionally, the last part of this thesis will take into account the disenchantment of society and the connections that can be drawn to the decline of artisan crafts, as well as their replacement by mass production. This part is kept short, as the broadness of these subjects provides enough material to write a thesis on its own about; rather, it focuses on the specific connections to artisan practices and their rise and fall.

This thesis will provide a framework and a source for artists looking to engage with alternative methods of combining both natural colours and photography and can, therefore, also serve as a technical manual as well as a collection of historical accounts and records.

Abstrakt

Těžiště této práce spočívá v kombinaci postupů spojených s extrakcí barev a alternativními fotografickými postupy; tato dvě historicky a umělecky významná řemesla se v průběhu dějin silně ovlivňovala. Kombinace obou je velmi specifická a klade otázky týkající se světlostálosti, fixace, aplikačních procesů a fotosenzitivních reakcí, z nichž všechny mají dlouhou historii jak ve fotografii, tak i v barvení a extrakci pigmentů.

Tato práce se zaměřuje na fotografické aplikace přírodních pigmentů, jejich historický vývoj (včetně různých metod kombinování propagovaných a využívaných umělci a vědci), ale také poskytne přehled chemických a molekulárních vlastností různých přírodních a umělých pigmentů.Diskutovaná témata budou ilustrovat spojení mezi tradičními technikami extrakce barev a novějšími fotografickými procesy inovovanými a vyvinutými v devatenáctém století, přičemž oba v současné době zažívají novou popularitu v celosvětovém měřítku.

Poslední část této práce navíc zohlední problematiku odkouzlení v kulturní a sociální teorii a souvislosti, které lze vyvodit z úpadku uměleckých řemesel a jejich nahrazování masovou výrobou. Tato část je krátká, protože rozsah těchto předmětů poskytuje dostatek materiálu pro psaní diplomové práce; spíše se zaměřuje na specifické souvislosti s řemeslnými postupy a jejich vzestupy a pády.

Tato práce poskytne rámec a zdroj pro umělce, kteří se chtějí zapojit do alternativních metod kombinování přírodních barev a fotografie, a může tedy sloužit i jako technický manuál i přehled historických dokumentů.

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Introduction

Returning to Old Ways

Whether it is a result of the fatigue induced by recent, past lockdowns or because people are simply becoming more interested in engaging with ancient (or at least older) practices, there is an observable, widespread, increasing tendency to take up a creative or nature-based hobby such as urban gardening, homemade cosmetics, pottery, beer brewing, and paper making. Of these practices, this thesis will focus on the revival of the ancient crafts of natural dyeing and pigment extraction as well as their connection to, and application with, photographic techniques. These colour-related crafts are fascinating from both a practical and a theoretical standpoint. Practically speaking, the various techniques of colour extraction, application, dyeing, and printing range from fairly simple mixtures of plant compounds and water to the more complicated processes of fermentation, temperature alterations, and colour changes resulting from factors such as oxidation. All of these variables directly tie in to what makes the theoretical aspect of this so fascinating; for while the molecular reactions that take place during dyeing, extraction, and application processes are, in part, very logical, they are also mind-bogglingly complex and difficult to comprehensively understand.

The historical connection to alchemy and later innovations in chemistry developed around various colour making practices brought on by complicated formulas, experiments and (at times) barely understandable notes, and similar scientific documents is one that cannot be overlooked; indeed, it creates a sense of mystique

around the subject. This connection also illustrates the importance attached to the source of creative raw material, thus modifying the role of the artist to include within it the role of the artisan; someone who not only creates something artistic, but also creates the very means required for creating art later on. This role is fundamentally just as important as that of the artist who will create using these innovations of colours, pigments, or printing techniques—and who may indeed be unaware of the tedious processes required to manufacture the raw materials so vital to their art.

At this present time, the amount of commercially available colours and their various hues is multitinduous; for all practical purposes the variety of colours available is seemingly endless. The wide variety of pigments available for use today are most often created artificially in a lab rather than through the extraction of natural, raw material. For this reason, engaging with the vast history of natural pigment extraction, as well as the many connections to photographic practices and light-sensitive reactions, is truly refreshing and eye-opening.

Upon researching further, it quickly becomes clear how strongly connected the history of the development of photographic techniques is to that of colour extraction from organic material to include plants and their various parts, earths such as clay, or semi-precious minerals like lapis lazuli. The first synthetic pigment, Prussian Blue, is of particular importance, even though it is derived from artificial rather than organic compounds. This pigment has, in its own way, concurrently shaped the history of chemistry, painting, and photography and is, therefore, one of the few artificially derived mineral pigments that will be further discussed in this thesis, specifically in subchapters 1.2.3 and 2.1.

While not quite lost, the knowledge of pigment extraction is one that still requires a significant amount of intensive research and scouring historical accounts of colour making, fabric dyeing, and paint mixing. However, it is worth noting that there is a sizable online community present on social media (especially on Instagram) whose primary foci are these exact crafts and their connected practices. Most of its members are happy to share their knowledge and answer any technical and theoretical questions, while some even conduct their own online and in-person workshops as well as producing blog posts and video tutorials on the subject. Therefore, while colour making, dyeing, and pigment extraction are all (by dent of their long and ancient history) a niche area of study, it is, with some initiative, still possible to access this knowledge even today.

Further complicating this difficulty is the attempt to take crafts connected to pigment extraction and dyeing and apply them to photographic printing and reproduction; the accounts for this particular method of working with organic pigments are fairly rare, and if there are any, they date back several centuries, especially with regard to their origins, initial discoveries, and related experiments. The cyanotype is one such photographic method that managed to essentially combine the vast history of the previously mentioned Prussian Blue with early photographic processes. The connected anthotypes use vegetable and flower juices as well as photosensitive reactions to imprint a positive film onto paper. Apart from this, there is little else that can successfully combine the two media; screen printing, however, is one such practice that can be used for both printing with naturally derived pigments and for

photographic reproduction, making it a suitable medium to experiment with the practical combination of both methods.

As mentioned above, sources containing detailed, classical knowledge surrounding these subjects may well require thorough research, however, these sources are by no means lost. Additionally, as previously stated, one can find many people willing to share their knowledge, whether in-person or over an online platform. Therefore, one can say that, whether by way of online courses[1], googling a step-by-step explanation or even by simply watching someone's Instagram highlights, knowledge has never been as generally accessible and readily shareable as it is today, and that also applies to the discussed subjects connected to the history of colour. In fact, the amount of readily available knowledge is, after some engagement with its connected practices, functionally endless. Complete volumes on the subject(s) can be easily downloaded via online resources, to include classics on pigment extraction, dyeing and printing techniques, 18th century manuals and nomenclatures of identified colours, or technical books thoroughly detailing mordant application.

This vast array of immediately accessible, online knowledge is expedient and practical, sparing the aspiring artisan or curious academic the time and physical effort of going into a brick-and-mortar location (e.g., a bookstore or library), while furnishing access to the desired information, which might have otherwise been lost to time or available only on a limited basis. It is, however, also overwhelming and exhausting, so numerous are the sources available within online repositories. Upon

[1] ABBAMONTE, Kiera. "The 11 best platforms to create and sell online courses in 2022". (Online) 8.12.21 (accessed 07.04.22) Available from https://zapier.com/blog/online-course-platforms/

beginning to research the theoretical roots of the history of pigment extraction and colour making as well as their applications and possible uses in photographic reproduction, one can start to differentiate between “contemporary’’ sources, which repeat and reiterate classical sources ad infinitum versus the original source documents themselves. The spectrum of these texts ranges from documents and accounts dating back Greek and Byzantine antiquity all the way to protocols and explicatory books written by colour chemists during the scientific revolution in the 19th and 20th centuries. Many of these are, fairly often, available for download as PDFs and ePub documents, mostly because they deal with very niche and rarely researched subjects. Because of this, they often do not have any costs associated with them and are considered part of the open-source, public archive. Some of the books used as references during the writing of this thesis were, however, much more difficult to locate, particularly Larry J. Schaaf‘s *Sun Gardens: Cyanotypes by Anna Atkins*[2], which deems itself the only (or most) reliable and extensive source on the life and accomplishments of Anna Atkins, about whom more will be said in 3.1.

The discourse on pigments and colour making (as well as the common knowledge of how old such practices truly are) pose the question of why, in a modern and developed society where colours are available in their purest forms and printing techniques are at the peak of their efficiency and quality, one would even consider learning and practising an old group of crafts such as colour making incorporates. A common, and arguably quite valid, reason one might become interested in learning a more primitive way of creating mineral and plant-based pigments from organic

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[2] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980

materials is the fear that civilization as it currently exists will crumble, capitalism will fall, and total anarchy will take its place[3].

History is full of examples of civilizations that have come and gone; this current, globalised, extant civilization of the anthropocene era would not be the first to have faced existential devastation, either by a natural disaster or by self-inflicted catastrophe. Global warming has been a known and deliberately dismissed problem for decades; only now (when it is already arguably too late) people in general and big companies in particular have begun taking action towards reducing their carbon footprint and creating less waste. It is therefore important, in the event of a complete socio-technological breakdown, to understand what our ancestors did to create the pigments with which they were then able to create art, document knowledge, and dye their fabrics for clothes—all three of which it would currently be impossible to imagine life without. Not that this interest in the practices of antiquity has limited itself the knowledge of colour making and pigmentation. A growing number of people are also becoming increasingly interested in how ancient civilizations used to eat before pasteurisation, how they used to farm cows and plants before the rise of factory farming and industrial agriculture, and how they used to (and still do) bake bread with dried baker‘s yeast. These enthusiasts cultivate hobbies and adopt habits such as animal-based or ancestral eating, foraging, growing fruit and vegetables in small spaces, or starting various ferments like sourdough and kefir and learning about their qualities. Sourdough, kefir, and kombucha especially are on the rise towards

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[3] SPECTOR, Brandon. ‘‘Society is right on track for a global collapse, new study of infamous 1970s report finds’’. (Online) 19.07.21 (accessed 08.04.22) Available from https://www.livescience.com/collapse-human-society-limits-to-growth.html

becoming a health trend and a popular hobby, as all of these bacterial cultures need feeding and care in order to be kept alive and viable. But all of this is ancient knowledge. Even as recently as a few centuries ago bread dough was fermented for as long as several weeks prior to consumption, water and milk were fermented to add beneficial bacteria, and vegetables and fruit were not available throughout the whole year. The return towards, and interest in, what civilizations used to practice is observable in many ways and plays a big role in the expectation of the fall of capitalism and the rise of a simpler, anarchic life.

This turn towards nature and a slower pace of life, however, has been a common standard throughout history and used to be a normal part of daily life. What is seen as “hip, cool and woke’’ today, especially by members of the upper-middle class living in urban areas, be it making one’s own watercolours, growing food in small spaces or baking sourdough bread, may be a necessity for lower-middle class families living in less accessible areas that do not tend to have the same salaries and opportunities as those available in more metropolitan areas. It is, therefore, important to note that many young people are, in fact, rediscovering what their parents and grandparents used to know and do: growing their own food, making their own food, preserving their food as well as knowing what to eat - which was necessary, for example, in Czechoslovakia, due to a lack of food availability at the markets. On that note, it is clearly visible how quickly capitalism has grown, and how strongly it has affected younger generations and the amount of basic, practical knowledge they have about life. The average consumer can easily exist without knowing anything about where their products come from, or how they were produced; this also applies to the artistic

compounds that artists tend to work with, such as commercially available paints and DIY sets. It does not matter to the average consumer, as long as the product serves its purpose and consumers' needs are met.

To that end, another interesting aspect of this renaissance of ancient crafts and practices discussed in this thesis lay in its capitalist nature, namely the monetisation of crafts and the rise of small businesses through websites like Etsy.com and its smaller, more locally oriented descendants.[4] This can also be observed in the paint-maker community. As mentioned earlier in this thesis, many members of this community will happily share their accumulated knowledge because they feel it is important to pass on what they have learned, so that others can have the opportunity to create something beautiful involving natural colours. There is, however, a small group of profit-oriented individuals that do not have any interest in sharing their technical and theoretical knowledge or their experiments and facts, because they have built a business around the monetisation of ancient crafts of watercolour making and clothes dyeing, to include giving paid workshops on related subjects. This attitude of secrecy is understandable to a certain extent; on the other hand, it polarises the community of natural colour practitioners, dividing it into one group that is glad to influence somebody else's creative path, and another that does not wish to share their particular knowledge of colour for fear of being copied and losing customers to competitors and industrial saboteurs. Of course, this phenomenon serves as an example not only for this body of work, but one that can be applied to

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[4] LUCKMAN, Susan. ‘‘The aura of the analogue in a digital age: Women's crafts, creative markets and home-based labour after Etsy’’. (Online) 01.03.13 (Accessed 08.04.20) Available from https://search.informit.org/doi/abs/10.3316/informit.273273712487637

any historical practice or craft that is making a comeback thanks to the formation of online communities dedicated to preserving and proliferating them.

The return to historical handmade processes can be observed in many aspects of life; this thesis will focus on the artistic aspect of life, specifically the combination of handmade media and alternative photographic techniques. This thesis is driven by an interest in the ancient craft of pigment making, the history of underrated photographic processes (such as anthotypes), and the many yet hidden artists that have worked with elements (e.g.,plants, earth or animal materials) and directly incorporated them into the process of creating their artwork.

On the other hand, this thesis will also explain the connection that can be drawn between said return to historical handmade processes and the historical disenchantment and current re-enchantment of society, which has been taking place since the dawn of the industrial revolution.[5] Taking into account important and forgotten parts of history such as the witch trials and burnings in Europe, this last part aims to further underline the importance of the comeback of ancient crafts and practices including pigment extraction and colour making, as well as the connection between witchcraft, female practices and the return to the spiritual and mystical practices that have been forgotten about for several centuries.

Not only will this thesis serve as a historical account of colour, pigments and the materials used for the various disciplines of printing, photographic processes, and painting linked to the strong, feminist history embedded in these categories, but it will

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[5] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences*. Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6

also serve as a reminder of the lack of connectively intertextual literary sources regarding the range of subjects discussed. One can find many books and articles about lake pigments, anthotypes and cyanotypes, but trying to find much information about the connection between photography and naturally derived pigments did not, as discussed earlier, yield many direct or useful results.

Therefore, this dissertation will pose questions about the lack of material connecting both of these historically important practices while attempting to search for connections that might have been lost over the course of history. Is there a connection between early dyeing practices and modern photography? Does this connection apply to specific colours of the spectrum? If yes, how and why? Are there historical accounts of artists working with natural pigments and photographic processes? Is this material useful, accessible and understandable? And how does the general history of colour extraction and paint making influence today's selection of artists' paints? These questions will be answered in the course of this thesis with the aim of providing a reliable and useful connective framework for artists from both disciplines who wish to experiment and combine the ancient crafts of pigment extraction and integrate those practices with photography-related techniques and processes.

1. Natural Colour in Visual Arts: Means of Extraction, Chemistry, and Application

Just as chemistry and science see atoms as the fundamental building blocks of the material world, so too do the arts regard pigments as the foundation of anything connected to visual creativity, because without colour, the world would not be more than a bland milieu of whites and greys. It is, therefore, necessary to devote a chapter to the history, extraction, chemistry and application of colours, specifically organic pigments and colours found and sourced in nature. However, given the importance of the development of pigments, as well as the gradual transition from natural to artificial colours, this chapter will also include some material on inorganic pigments and their history.

Pigments are classified using various characteristics like colour, use, or lightfastness, however they can be divided into two main categories, labelled according to their origin as either organic and inorganically derived.[6]

1.1 Organic Pigments

This class of pigments can be categorised into three distinct subgroups: those of plant descent (madder, indigo, etc.), those of animal descent (cochineal, Indian yellow, etc.) and artificially prepared organic colours (anilines, alizarin, etc.).[7] All three of these subdivisions can be created by different means of extraction, but the most

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[6] MAYER, Ralph. *The Artist's Handbook of Materials and Techniques*. New York, USA: The Viking Press, 190. ISBN 670-13665-4, p. 36

[7] Ibid.

popular method by far, as well as the one with the most research and lab reports attached to it, is the method known as “lakeing’’.

1.1.1 Lake Pigments

Generally speaking, lake pigments are ‘‘*compounds of some animal or vegetable colouring matter with an inorganic base.”* [8] Lake pigments are insoluble by water, may be mixed with a medium for painting and printing, and are usually not very lightfast. They are created through the reaction of a metallic compound, aluminium sulfate (alum) for example, and a basic compound, like sodium bicarbonate or potash, in a strongly concentrated dye bath; the precipitation reaction forms a new mineral, aluminium hydroxide, which in itself is colourless, but in this case absorbs the colour of its environment.[9] Aluminium is commercially derived from an important naturally occurring ore, the alum rock, and is used as a mordant in dyeing practices,[10] as discussed in 1.4. Alumina Hydrates are commonly described as ‘‘*a basic aluminium sulfate prepared as a precipitate from solutions of aluminium sulfate and sodium carbonate”*.[11] The aforementioned reaction leaves a cloudy solution, wherein the resultant aluminium hydroxide starts to settle, leaving behind a clear liquid on top that can be discarded. The sediment itself is then filtered, dried, and pulverised.

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[8] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 194

[9] EASTAUGH, Nicolas et. Al. *Pigment Compendium: A Dictionary of Historical Pigments*. Burlington, MA, USA: Elsevier Butterworth-Heinemann Linacre House, 2004. ISBN 0 7506 57499, p. 8

[10] Ibid., p. 9

[11] PATTON, T. C. *The Pigment Handbook*. 1973. New York, USA: John WIley & Sons, 1988. ISBN 978-0-471-82833-4

Lake pigments were first known as ‘‘lacs’’. In earlier times, Italian dyers had to fix the colour on the fibre using mordants.[12] Mordants are of metallic nature and help the colour compounds hold onto fabric and other material; today, natural dyers mostly use aluminium sulfate or iron, both of which can have an effect on the final colour of the pigment/dye bath. During this period, salts of aluminium and tin were the most suitable for the purpose, and the insoluble mineral compounds of colours and bases formed a thin layer of scum on the surface. This was then scooped off and sold to artists under the name of *lacca.*[13]

1.1.2 Pigments of Plant Descent

Pigments extracted from plant material are probably the oldest means of colouring, especially with regard to dyeing cloth and other materials. Yellow and orange are probably the easiest colours to access; different **marigolds** (French, Mexican), **onion skins**, **wood sorrel** (*Oxalis stricta*) and **goldenrod** (*Solidago*) are only a few examples of the plant materials that yield said tones.[14]

Indigo holds a place of great importance as a plant-derived pigment as well as a major dye, known for its deep blue shade and boasting an extensive, vast history of origin and preparation. The blue pigment is derived from the leaves of various *Indigofera* species native to areas such as India, South and Central America, and

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[12] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 195

[13] Ibid.

[14] Conclusions from author’s own experiments

Asia, the most commonly used species being *Indigofera tinctoria*.[15] Another version of Indigo was derived from several species of **woad** or *Isatis*, namely *Isatis tinctoria* (native to the Mediterranean and Western Asia), *Isatis indigota* (native to China) or *Polygonum tinctorium* (native to Eastern Asia, also known as Dyer‘s Knotweed).[16]

The preparation of Indigo dye is a fairly long and complicated process; it is first steeped in hot water (woad does not require heat), to which an alkaline compound like potash or bicarbonate of soda has been added.[17] The soaked leaves are then beaten to a slurry and left to ferment and oxidise; the indigo then forms an insoluble precipitate, which is filtered, dried, and often formed into balls before further use and pulverisation.[18]

Another well-known dye plant is **madder** (*Rubia tinctorium*); sourced from the roots of the plant, its deep, rusty to orange-red colour has been prized for hundreds of years, by offering access to cheap red dye to Europeans.[19] Madder contains anthraquinone components which give it its deep red colour, including alizarin, purpurin and rubiadin, amongst many others.[20] While being best known for its red colour, madder has the capability of yielding a variety of hues, ranging from yellow and orange over said red tones, all the way over to purple or brown; this depends on the preparation

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[15] EASTAUGH, Nicolas et. Al. *Pigment Compendium: A Dictionary of Historical Pigments*. Burlington, MA, USA: Elsevier Butterworth-Heinemann Linacre House, 2004. ISBN 0 7506 57499, p. 194

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Ibid., p. 244

[20] Ibid.

of the concentrated ink, specifically on the mordants and modifiers applied in the process.[21]

Brazilwood has been used in the forests of Brazil and Mexico to create shades of bordeaux red and crimson-like colours, while the Mexican equivalent **logwood** yields blue-purple tones.[22] Logwood (*Haemotoxylum campechianum* or *H. brasiletto*) is native to Central America and the West Indies, and was first discovered by European explorers around the Mexican city of Campeche on the Yucatan Peninsula, which gave the colour its name.[23] Logwood consist of 10% hematoxylin[24], with tannins and resins present; during the dyeing process, the hematoxylin oxidises into haematin, a strongly pH sensitive compound that, for this reason, offers a great variety of colours, ranging from red to purple over blue to black.[25] Brazilwood (*Caesalpinia* or *Haematoxylum*) is a group of brown-red hardwoods with a long history in dyeing and pigment production; the material yields a red colour created by the colouring agent

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[21] Ibid., ‘‘*Gentele (1860) states that partial precipitation of madder dye with soda or potash gives a deep red colour while a complete precipitation gives a lighter lake, adding that this is also true for chalk precipitates and that the intensity is increased if a small amount of tin is added at the end of precipitation. Cremer (1895, cf. Chenciner, 2000) further states that the addition of iron sulfate results in black violet and madder violet. Chromium alum gives a red-brown and iron salts in the alum also produce a brown colour.”*

[22] Ibid. p. 73, 242

[23] Ibid. p. 242

[24] WIKIPEDIA. ‘‘Haematoxylin“ (Online) Last edited 17.10.21 (Accessed 08.04.22) Available from https://en.wikipedia.org/wiki/Haematoxylin

[25] EASTAUGH, Nicolas et. Al. *Pigment Compendium: A Dictionary of Historical Pigments*. Burlington, MA, USA: Elsevier Butterworth-Heinemann Linacre House, 2004. ISBN 0 7506 57499, p. 242

brazilin that, upon autoxidation[26], turns into the dye brazilein.[27] It is not, however, a very lightfast dye, and has, therefore, been replaced by artificially derived reds.[28]

1.1.3 Pigments of Animal Descent

The best known example of this category of organic pigments is probably **cochineal**, which is used for the preparation of colours like crimson and scarlet lakes.[29] Carmine, the active colouring compound of cochineal lakes, is extracted from females of the insect *Coccus cacti*, native to the cacti of Mexico; it played a significant role in the Spanish conquests of South America, which is also how it was first believed to have been introduced to Europe.[30] Carmine is the colour of fine and deep scarlet red and is said to always yield a bright and fiery tint, however the pigment is not permanent to light and air.[31]

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[26] WIKIPEDIA. ‘‘Autoxidation’’ (Online) Last edited 14.02.22 (Accessed 08.04.22) Available from https://en.wikipedia.org/wiki/Autoxidation

[27] EASTAUGH, Nicolas et. Al. *Pigment Compendium: A Dictionary of Historical Pigments*. Burlington, MA, USA: Elsevier Butterworth-Heinemann Linacre House, 2004. ISBN 0 7506 57499, p. 60

[28] Ibid.

[29] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 196, 197, 203, 206

[30] Ibid., p. 196

[31] Ibid., p. 198 - 199

The European version of cochineal is **kermes**, namely the bodies of the *Coccus illicis*,[32] living in a parasitic state on the kermes oak (quercus coccifera)[33], which is said to produce more of a blood red than cochineal.[34]

Another animal-derived pigment of historical importance is the ancient purple derived from **purpura snails**, the most commonly used species being *Murex brandaris* and *Murex trunculus*, both of which are found in the Mediterranean Sea.[35] For centuries, beginning as early as the time of Moses, the purple produced in Tyre was known the world over. It was considered to be the colour of royalty, reserved only for the elite of the time. Even with an increase in the production of purple fabric and garments, it was primarily reserved for the more affluent members of society, while the relationship of the poor to this commercial enterprise usually consisted of performing the long and unappetising process of extracting the valuable purple dye.[36] Alexander Dedekind,[37] a German Egyptologist, became interested in studies on the purple dye; he was the first to transcribe whatever historical accounts he could find on the pigment, the earliest being Aristotle who talks about the advantages of light in dyeing

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[32] CENNINI, Cennino. *The Book of The Art of Cennino Cennini: a Contemporary Practical Treatise on Quattrocento Painting*. London, UK: George Allen Ruskin House, 1899. p. 252

[33] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 196

[34] CENNINI, Cennino. *The Book of The Art of Cennino Cennini: a Contemporary Practical Treatise on Quattrocento Painting*. London, UK: George Allen Ruskin House, 1899. p. 253

[35] EDER, Josef Maria. *History of Photography*. New York, USA: Dover Publications, 1978. ISBN 0-486-23586-6, p. 8-9

[36] Ibid., p. 9

[37] WIKIPEDIA. ‘‘Alexander Dedekind’’. (Online) Last edited 04.11.20 (Accessed 08.04.22) Available from https://de.wikipedia.org/wiki/Alexander_Dedekind

with purple or the Sophist Philostratos who mentions the dark colour of Tyrian Purple and its connection to the sun.[38]

One of the most interesting aspects of the dye produced by the glands of the *Murex* snails is its photochemical character. When first extracted, the colour produced by the glands is a pale green, as observed by William Cole of Minehead, United Kingdom: ‘‘*(…) their juice, when spread on linen or silk, produced first a greenish colour, which changed rapidly to dark green and light purple, which turned in a few hours under bright skies to a deep purplish red.”* [39]

Several scientists worked with similar species of snail in parts of Western Europe, including France and the United Kingdom.[40] P. Friedlander, in 1909, concluded that the chemical compounds of the ancient purple dye were molecularly related to those of indigo; it was he who finally answered the final questions about this oldest and most valuable dye in history.[41]

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[38] EDER, Josef Maria. *History of Photography*. New York, USA: Dover Publications, 1978. ISBN 0-486-23586-6, p. 10, *“The oldest accounts, as Dedekind proves, are those of Aristotle, who relates, in his work on colours, the advantageous influence of light in purple dyeing. (…) and Philostratos, a Greek Sophist from Lemnos, (…) writes in his book Imagines: "The purple of Tyre looks dark and derives its beauty from the sun, which gives it the shade of a pomegranate blossom."*

[39] Ibid., p. 12

[40] Ibid.: *“Here we are indebted to William Cole, of Minehead, England, who discovered on the shores of Somersetshire and South Wales shellfish (Buccinum) containing purple. (…) Reaumur found a great many Buccina on the coast of Poitou and published in 1711 in his treatise* Sur une nouvelle pourpre*, his observations of the important part which light plays in the formation of red colour.”*

[41] Ibid., p. 14, *“Analysis showed that the purple dye was to be considered as a dibromo derivative of indigo or an isomer indirubin.”*

1.1.4 Artificially Prepared Organic colours

Alizarin is the active body in the madder plant giving its colour, though it has been synthetically derived from anthracene for a long time[42]. It has replaced all red lakes since the start of its commercial production in the 1920s,[43] including other historically important plant-derived red lakes such as brazilwood or madder.

The compound **aniline** was first synthesised around 1860, and is used together with aniline hydrochloride and sodium chlorate in the presence of an oxidation catalyst; a black dye is then developed at a temperature of 60 to 100 degrees Celsius in conjunction with further oxidation using sodium chromate.[44] There was, however, an already extant compound called aniline black dating back to 1856; this version contained a slightly different array of chemicals, and was used as a source from which to extract aniline violet. Aniline black is still widely used today, especially when carbon-based blacks are deemed inappropriate.

1.2 Inorganic (Mineral) Pigments

Once again, three categories can be formed from a class of inorganic pigments: those made of native earths (ochre, raw umber, etc.), those made of calcined native

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[42] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 16

[43] MAYER, Ralph. *The Artist's Handbook of Materials and Techniques*. New York, USA: The Viking Press, 190. ISBN 670-13665-4, p. 91

[44] EASTAUGH, Nicolas et. Al. *Pigment Compendium: A Dictionary of Historical Pigments*. Burlington, MA, USA: Elsevier Butterworth-Heinemann Linacre House, 2004. ISBN 0 7506 57499, p. 13

earths (burnt umber, burnt sienna, etc.) and those made of artificially prepared mineral colours (cadmium yellow, zinc oxide etc.).[45]

As mentioned above, lake pigments are technically mineral pigments, since they are insoluble by water and are mostly made of aluminium hydroxide or a similar salt, which in itself is a mineral. They are, however, described under the category of organic pigments, because the most popular material used for their production is of either plant or animal origin.

1.2.1 Pigments Made of Native Earths

The other kind of mineral pigments are those made directly from pulverised soil, rock, or clay, all of which can naturally contain salts, minerals, and oxides that influence the colour appearance of the material.

One famous example of a widely used historical mineral pigment is **Ultramarine Blue**, which is made by grinding lapis lazuli into a fine powder. According to Ernest J. Parry, "*Lapis Lazuli (…) is occasionally found with gold-like fragments of iron pyrites interspersed through its substance. To prepare the pigment, the mineral is broken into small pieces, freed as much as possible from mechanically adhering impurities, heated in a crucible and thrown into cold water or very weak vinegar. It is then washed by decantation, dried, ground and then purified by elutriation, by which process various grades of colour, from the finest blue to grey ultramarine ash, are obtained."* [46]

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[45] MAYER, Ralph. *The Artist's Handbook of Materials and Techniques*. New York, USA: The Viking Press, 190. ISBN 670-13665-4, p. 36

[46] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 165

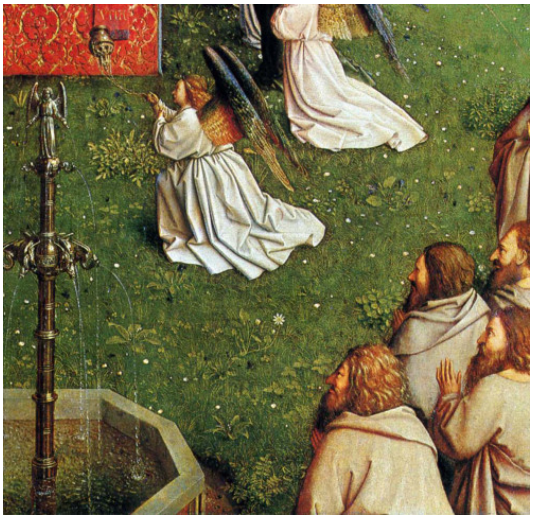

Figure 1 (left): *Saint Francis of Assisi Receiving the Stigmata*, 1430-1432, Jan van Eyck. Figure 2 (right): Detail of *Adoration of the Mystic Lamb*, 1432, Jan Van Eyck. Both paintings use Verdigris, also called copper acetate, a green-blue pigment formed by the exposure of copper to acetic or formic acid.[47] These images illustrate the difference in lightfastness that one colour can produce over time.

Yet another series of well-known pigments made from native earths are the **ochres**, historically prized for the deep, golden tint resulting from their high content of hydrated iron oxide (**yellow ochre**) as well as their red hues, which are coloured by anhydrous oxide (**red ochre**).[48] **Blue ochre** is made from the mineral vivianite, described by Salter as *"a native hydrated phosphate of iron of rare occurrence, found with iron pyrites in Cornwall, and also in North America*"[49] and is also referred to as

[47] EASTAUGH, Nicolas et. Al. *Pigment Compendium: A Dictionary of Historical Pigments*. Burlington, MA, USA: Elsevier Butterworth-Heinemann Linacre House, 2004. ISBN 0 7506 57499, p. 385

[48] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 128

[49] SALTER, Thomas W. *Salter's Edition of Field's Chromatography; or, Treatise on Colours and Pigments As Used by Artists*. London, UK: Windsor & Newton, 1869. (Online) Available from https://play.google.com/store/books/details?id=hy4DAAAAQAAJ&rdid=book-hy4DAAAAQAAJ&rdot=1 p. 226

‘‘native Prussian Blue’’ (1.2.3), even though Salter notes that the pigment has no connection to Prussian Blue itself.[50]

1.2.2 Pigments Made of Calcined Native Earths

Burnt umber is made by roasting raw umber in an oxidising environment, which dehydrates the iron hydroxide particles and converts them into iron oxides, yielding a warm reddish-brown colour.[51] Sources tend to forget the distinction between raw and burnt umber,[52] which in itself is brown due to its significant amount of manganese oxide.[53]

Another pigment made from the calcined and oxidised equivalent of a naturally occurring mineral pigment, **burnt sienna**, is another warm reddish-brown derived from raw sienna,[54] which is similar to yellow ochre in colour but differs chemically by containing less than 10% manganese oxide.[55] Burnt sienna has been found on paintings from the Greek and Byzantine eras and was commonly used in both Europe, where it was sourced from Italy, as well as America.[56]

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[50] EASTAUGH, Nicolas et. Al. *Pigment Compendium: A Dictionary of Historical Pigments*. Burlington, MA, USA: Elsevier Butterworth-Heinemann Linacre House, 2004. ISBN 0 7506 57499, p. 55

[51] Ibid. p. 66

[52] Ibid.

[53] Ibid. p. 377

[54] Ibid., p. 66

[55] Ibid., p. 339

[56] Ibid., p. 66

1.2.3 Artificially Prepared Mineral Pigments

Artificially prepared mineral pigments are those most commonly used today; their production has been deemed to be cheaper and quicker than many lakeing processes or excavations from the soil. The list of artificially prepared mineral pigments is a one of daunting length; there is, however, one pigment that is particularly important for the development of photographic methods, which subject is the primary focus of this subchapter.

As mentioned above, an example of artificially derived mineral colours is **Cadmium Yellow**, which consists of cadmium sulphide; this pigment is an example of an artificial pigment that was not used for very long due to its tendencies to either darken on exposure to air and light or bleach on exposure to moisture. The historical accounts of Cadmium Yellow are, however, inconsistent. The pigment was first officially recognised in 1819, but it was not commercially available until the 1840s due to the rarity of the metal required for its production.[57]

Prussian Blue is probably the most fascinating of the artificial pigments, especially for those interested in the history of photography. Its use for cyanotypes has made it one of the few pigments to have found its way into the field of photography. This chapter will delve into the history of Prussian Blue, or Berlin Blue as it is also called, as well as its chemical traits, properties, and the incredible influence it has had on the world.

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[57] Ibid., p. 72

The discovery of ferric ferrocyanide, or iron(III) hexacyanoferrate (II)[58], is the story of a happy accident. In 1704, Heinrich Diesbach, a Swiss chemist and paint maker residing in Berlin, tried to synthetically prepare a crimson lake, which, as discussed in 2.1.3, was originally made from crushed cochineal beetles. However, he ran out of potash, most probably potassium alum, which is needed for the proper extraction of dye from most materials. Diesbach decided to borrow some from a well-known alchemist, Johann Konrad Dippel.[59] Dippel was known for his strange medicinal ‘‘animal oil’’ (also known as ‘‘Dippel‘s Oil’’), a distillate of a number of animal-derived elements like bones, blood, and other bits of carcass. Dippel’s potash was most probably contaminated with some of that oil because the reaction it caused in Diesbach‘s extraction was both unexpected and revolutionary. Instead of turning the lake red, Diesbach created the deepest blue he had ever seen and, with that accidental contamination, the first pigment to ever be extracted artificially.[60]

The story of Prussian Blue did not, however, end here; its discovery led to the (again accidental) detection of cyanide. In 1782, Carl Wilhelm Scheele, a Swedish scientist also known for discovering oxygen and arsenic acids[61], coated a spoon in traces of sulphuric acid and used it to stir a pot of Prussian Blue and unknowingly created one of the most potent poisons of the modern era.[62] Fritz Haber, one of the founders of

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[58] WARE, Mike. *Prussian Blue: Artists' Pigment and Chemists' Sponge*. Journal of Chemical Education 85, no. 5 (2008): p. 612 - 620. Available from https://doi.org/10.1021/ED085P612, p. 612

[59] Ibid.

[60] Ibid.

[61] BRITANNICA. By Anders Lundgren. „Carl Wilhelm Scheele“. (Online) Last updated 05.12.21 (Accessed 08.04.22) Available from https://www.britannica.com/biography/Carl-Wilhelm-Scheele

[62] LABATUT, Benjamin. *When We Cease to Understand the World*. London, UK: Pushkin Press, 2020. (EBook) ISBN 9781681375670. Available from https://1lib.cz/book/17047811/7d4fea, Chapter 1 p. 17

the Haber-Bosch process, famous for combining nitrogen and hydrogen to form ammonia in large enough quantities for use in the commercial production of fertiliser and munitions[63], was also the mind behind the most destructive pesticidal fumigant ever created, dubbed *Zyklon*, the German word for *cyclone*.[64] The research Haber did to create this pesticide was then used for the production of *Zyklon B*, which essentially consisted of larger quantities of the hydrogen cyanide based gas; this time, however, it was not used to eradicate insects, but rather to eradicate humans.[65]

Figure 3: Formation of Prussian Blue.

The use of *Zyklon B* as a mass-eradication gas in concentration camps[66] became part of one of the most gruesome and horrifying events in human history. How

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[63] BRITANNICA. By William B. Jensen. „Fritz Haber“. (Online) Last updated 25.01.22 (Accessed 08.04.22) Available from https://www.britannica.com/biography/Fritz-Haber

[64] LABATUT, Benjamin. *When We Cease to Understand the World*. London, UK: Pushkin Press, 2020. (EBook) ISBN 9781681375670. Available from https://1lib.cz/book/17047811/7d4fea, Chapter 1 p. 31

[65] Wollheim Memorial. ‘‘Zyklon B: An Insecticide Becomes a Means for Mass Murder’’. (Online) Date unknown. (Accessed 08.04.22) Available from http://www.wollheim-memorial.de/en/zyklon_b_en_2

[66] BASF. „Chemical Warfare Agents and Zyklon B“. (Online) Date unknown. (Accessed 08.04.20) Available from https://www.basf.com/global/en/who-we-are/history/chronology/1925-1944/1939-1945/kampfstoffe-und-zyklon-b.html

fascinating, but at the same time horrendous, that such a simple thing as a pigment can wreak so much devastation. Were it not for Dippel's animal oil contaminating his raw material and Diesbach's desire to create a deep red, as well as his failure therein, and the accidental discovery of Prussian Blue, history may well have taken a different turn.

The discovery of Prussian Blue was certainly a ground-breaking one, and not only because it was the first blue pigment that was readily available as well as affordable. Before its accidental discovery, the colour blue was derived from indigo (or woad in European countries), which was problematic because it was prone to fading.[67] Ultramarine, the pulverised semi-precious mineral lapis lazuli, was exceedingly expensive because it was only mined in Afghanistan, and its use was, therefore, reserved for the elite.[68] With the arrival of Prussian Blue, artists finally regained some freedom on their palette; the use of blue in paintings started to steadily rise and could be observed especially in the works of the French Impressionist School.[69]

Prussian Blue is famous not only for its rich colour but also for its molecular particularities; it has a zeolytic character, described by Mike Ware as: *"Zeolites belong to a complex family of porous alkali metal aluminosilicate minerals, but the adjective is now applied to any substance capable of taking up and trapping other molecules or ions in the cavities of its lattice, and acting as a molecular sieve or ion*

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[67] WARE, Mike. *Prussian Blue: Artists' Pigment and Chemists' Sponge*. Journal of Chemical Education 85, no. 5 (2008): p. 612 - 620. Available from https://doi.org/10.1021/ED085P612, p. 615

[68] Ibid.

[69] Ibid.

exchanger."[70] It is also important to note that Prussian Blue is the only known antidote for the very powerful poison, thallium, which mimics the nutritional element potassium and passes through the gut wall; Prussian Blue has the ability to trap the harmful ion of thallium in its lattice on a molecular level, which allows it to be safely excreted by the body.[71] Another potent poison this pigment can deactivate is cesium, a strong radiotoxin that can linger in the body for up to 110 days.[72] When Chernobyl's nuclear reactor exploded in April 1986, a radioactive cloud containing cesium, amongst other toxins, made its way across Europe and all the way to the English grasslands.[73] To protect cesium from entering the human body, English sheep were fed Prussian Blue, so they would not absorb the cesium present in their environment and food.[74] Even in Norway, the aftereffects of Chernobyl could be detected in the local reindeer population; saltlicks containing Prussian Blue were distributed across the affected areas, quickly yielding positive results.[75]

The last chapter of the history of Prussian Blue that shall form a part of this thesis is the history of cyanotypes, which can be found under 2.1.

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[70] WARE, Mike. *Prussian Blue: Artists' Pigment and Chemists' Sponge*. Journal of Chemical Education 85, no. 5 (2008): p. 612 - 620. Available from https://doi.org/10.1021/ED085P612, p. 612

[71] EMSLEY, John. *The Elements of Murder - A History of Poison*. New York, USA: Oxford University Press, 2005. ISBN 0-19-280599-1. p. 338 - 339

[72] WARE, Mike. *Prussian Blue: Artists' Pigment and Chemists' Sponge*. Journal of Chemical Education 85, no. 5 (2008): p. 612 - 620. Available from https://doi.org/10.1021/ED085P612, p. 615

[73] Ibid.

[74] IAEA. „Caesium". (Online) Date and author unknown. (Accessed 08.04.20) Available from http://f40.iaea.org/worldatom/Press/Focus/Chernobyl-15/caesium.pdf

[75] STAMSTAG, Tony. BBC News. „Norway's radioactive reindeer". (Online) Oslo, Norway: 24.12.00 (Accessed 08.04.22) Available from http://news.bbc.co.uk/1/hi/world/europe/1086547.stm

1.4 Acid and Alkali: Properties and Alterations

"These are two groups of active chemical substances which are strongly opposite and may be considered widely divergent poles of action." [76] Pigments, dyes, and paints are strongly dependent on their pH level, namely their alkaline or acidic properties. Thus, the final colour of a pigment can vary greatly depending on the geography and ecosystem of its creation, which can be directly tied to differences in the quality of water and varying pH levels.

In natural dyeing, mordants are used for fixing the natural colour to the desired fabric or material. The most common mordants are aluminium sulfate and iron; aluminium tends to lighten the final outcome of the colour while iron tends to darken it. Aluminium is the substance that has an effect on the pH level of the dye solution; iron merely influences the permanency and the nature of the colour.

Another important practice is the use of modifiers, which is exactly where the pH level starts to play a big role. Citric acid can, for example, be used to change a colour by shifting its pH level to acidic; again, acidic compounds often lighten the final outcome due to their bleaching properties. They may also completely change the colour of a dye solution, but all that is again dependent on the original pH level of said solution. Blue pigment extracted from purple carrots, for example, turns bright pink upon the addition of citric acid to the binding base and the pigment;[77] this is due to the presence of anthocyanins, which can appear blue, pink, purple, or even black. Alkali

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[76] MAYER, Ralph. *The Artist's Handbook of Materials and Techniques*. New York, USA: The Viking Press, 190. ISBN 670-13665-4, p. 441

[77] Conclusions from author's own experiments

compounds, however, are more unpredictable and can alter the final colour in a pigment drastically. However, they sometimes have no effect at all and leave the colour as it originally was, which again varies according to the local pH level of the water used.

1.5 Binding Methods for Printing Media

The following binding solutions are suitable for use with various printing methods because they connect a pigment with a base and thereby create a paste-like blend. Often, the consistency of the paste can be altered until it is suitable for the reproductive printing of photography, the screen printing method, for example. In this process, it is crucial to ensure that the size of the pigment particles is suitable for the screen being used for printing; sufficiently pulverising the extracted pigment is of utmost importance for a clean and even print. The pigment is incorporated into the base using a paint muller[78] on a suitable surface such as a sheet of glass; the finished paint is then either put into tubs and dried, as is common with aquarelle colours which are used with water, or kept in tubs for later direct use, such as oil and tempera paints or watercolours for printing.

This chapter focuses specifically on binding methods for the possible reproduction of photographic images using naturally derived pigments, and will, therefore, leave out application methods like crayons, pastels, and frescos, all of which do, however, have a long tradition tied to the arts, painting, and colour studies.[79]

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[78] MAYER, Ralph. *The Artist's Handbook of Materials and Techniques*. New York, USA: The Viking Press, 190. ISBN 670-13665-4, p. 150

[79] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 49

1.5.1 Watercolour Base

A watercolour base usually consists of a set ratio of a gum compound and glycerin combined in water[80]; other substances such as honey, clove oil, and ox gall liquid may be added for additional benefits during use.[81] Watercolour bases allow for easy manipulation on the painting medium using multiple layers of colour washes, for example, which changes the depth and intensity of the colours.[82] They can also be easily diluted with water, permitting experiments involving factors such as opacity and colour strength. Additionally, paintings created using a watercolour base are much more susceptible to environmental and atmospheric influences than works that are varnished or otherwise embedded in some form of a protective layer, which is why the medium is rarely used for works that are supposed to last a long time.[83]

Honey and clove oil both act as antibacterial compounds, prolonging shelf life, while ox gall liquid ensures proper dispersion of the pigment within the base body. These simple solutions of gum and glycerin are fairly powerful adhesives; they bind the pigment into a mass and attach it to the ground, however their durability over time is rather inadequate.[84] For reproducing photography using the screen printing method, on the other hand, a watercolour base is a suitable choice, as the drying process is

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[80] Ibid.

[81] HATCH, Evie. ‘‘Making Handmade Watercolours with Jackson‘s Artist Pigments’’. (Online) 25.09.20 (Accessed 08.04.20) Available from https://www.jacksonsart.com/blog/2020/09/25/making-handmade-watercolours-with-jacksons-artist-pigments/

[82] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 54

[83] Ibid.

[84] MAYER, Ralph. *The Artist‘s Handbook of Materials and Techniques*. New York, USA: The Viking Press, 190. ISBN 670-13665-4, p. 6

fairly quick and allows for additional experiments, like those involving layering, for example.

1.5.2 Oil Bases

Oil bases are very straightforward and are exactly what the name implies: a pigment mixing base consisting of an oil. Popular oils for use as a base include linseed and poppy seed, both of which have a long and storied history of use in the medium of painting, as well as other vegetable, nut, and seed based oils like walnut or hemp seed.[85] Oil paints are popular for the ease with which they can be modified using transparent layers of paints and glazes, as well as their relative constancy of colour upon drying; however, there are disadvantages, to include possible yellowing during longer periods of storage, as well as of the paint film cracking with age, all of which can although be avoided through proper handling of the materials and adherence to technical procedures.[86]

Dried oil films have the ability to enclose the pigment in a solid, glossy and continuous substance that slightly reflects light sources and adds a lively touch to the image.[87] Using, once again, the example of screen printing (as it is a very accessible medium for photographic reproduction), oil bases are best used for charcoal or soot pigment, because both are hydrophobic and oil-based, and, therefore, will not

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[85] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 61, 64

[86] MAYER, Ralph. *The Artist's Handbook of Materials and Techniques*. New York, USA: The Viking Press, 190. ISBN 670-13665-4, p. 126

[87] Ibid., p. 6

appropriately disperse the pigment particles in a water-based medium; an oil-based pigment is best mixed with an oil-based paint base.

1.5.3 Tempera Bases

Tempera, also called distemper painting, is essentially in-body colour, usually employed on surfaces such as wood, linen stretched on wood, or plaster.[88] When used on wood and linen, the surface is primed with whitening and left to dry prior to painting.[89] The early Byzantine school utilised honey and glue to bind their pigments, which was ultimately deemed inadequate due to the tinted nature of the material; only when Giotto introduced a less coloured medium, namely egg white or white and yolk together,could colour be mixed with much greater purity and less tinting than was possible with previous methods.[90]

The longevity of tempera based paints, however, leaves much to be desired because the delicate nature of the paints does not leave a lot of room for modification, unlike other medium such as watercolours, which can be manipulated with washes, or oil paintings whose physical appearance can be altered with the use of varnishes and glazes over the finished works.[91] Additionally, due to several chemical properties of tempera paints, environmental and atmospheric factors will most certainly influence the final look of the painting; its putrescible[92] nature makes it prone to mould and

[88] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-628142, p. 55

[89] Ibid.

[90] Ibid.

[91] Ibid.

[92] DICTIONARY. „Putrescible“. (Online) 2022 (Accessed 08.04.22) Available from https://www.dictionary.com/browse/putrescible

decay, cracking and scaling may happen due to the fluctuation of moist and dry air which is absorbed by tempera bases because of their hygroscopic[93] nature; additionally, they contain sulphur, which may cause the blackening of certain mineral colours resulting from the formation of hydrogen sulphide[94] during decay.[95]

[93] DICTIONARY. „Hygroscopic“. (Online) 2022 (Accessed 08.04.22) Available from https://www.dictionary.com/browse/hygroscopic

[94] DICTIONARY. „Hydrogen Sulphide“. (Online) 2022 (Accessed 08.04.22) Available from https://www.dictionary.com/browse/hydrogen-sulphide

[95] PARRY, Ernest J. *The Chemistry of Pigments*. London, UK: Scott, Greenwood & Son, 1902. ISBN 9-781444-62814, p. 56

2. Natural and Synthetic Colour in Photographic Processes

The history connecting photographic practices with the use of natural colours is both vast and extensive; the influence of sunlight on various plant and animal derived dyes and pigments is a phenomenon that has been studied since ancient Greek and Roman times.[96]

The two main processes that will be discussed in this thesis are the cyanotype and the anthotype process, both of which share a historical connection and are crucially important when it comes to the development of photography, as well as to female influences on the history of photography.

2.1 Cyanotypes

The process of cyanotypes was invented by Sir John Frederick William Herschel in 1842, only about three years after Daguerre and Talbott announced their silver photographic processes.[97] Generally speaking, the history of the cyanotype is a continuation, or rather a whole branch of the history, of the first artificial pigment, Prussian Blue, as discussed in 2.2.3.

John Herschel, a highly intelligent polymath active in the fields of photography, mathematics, chemistry, astronomy, drawing, philosophy, music and botany, is a key player in the history of photography, having strongly influenced its development in several areas: he coined the terms *photography*, *negative*, *positive* and *snap-shot*,

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[96] EDER, Josef Maria. *History of Photography*. New York, USA: Dover Publications, 1978. ISBN 0-486-23586-6, p. 8

[97] WARE, Mike. *Cyanomicon - History, Science and Art of Cyanotype*. (Online) OCLC 1044748730. 2020 (accessed 03.2022) Available from https://www.mikeware.co.uk/downloads/Cyanomicon.pdf, p. 10

and was either involved in, or directly responsible, for the discovery of the chrysotype, ambrotype, tintype and, as will be discussed in this chapter, the cyanotype and anthotype processes.[98]

Cyanotypes and their process are based on photochemical reactions, but the exact formula that Herschel originally used has never actually been cited. One finds in his notes, however, that Herschel ‘‘*explored at least fifteen chemically distinct ways of making images in Prussian blue.”* [99] During Herschel’s process of discovery, his friend and fellow chemist, Alfred Smee, was generous enough to provide him with a bright red, complex salt, potassium ferricyanide. When Herschel put a paper coated in a solution of Potassium ferricyanide into direct sunlight, he was astonished to see that the bright red salt turned blue upon exposure; Herschel had created Prussian blue.[100] With the creation of Prussian Blue, Herschel began experimenting with photograms of carvings.[101] Some time into his experiments, Smee informed Herschel about the availability of a new substance, ammonium ferric citrate, which he found to be even more light sensitive.[102] Thereafter, Herschel’s final recipe for the coating of cyanotype paper consisted of a mixture of ammonium ferric citrate and potassium

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[98] FABBRI, Malin. *Anthotypes: Explore the Darkroom in Your Garden and Make Photographs Using Plants*. Stockholm, Sweden: Malin Fabbri, AlternativePhotography.com, 2012. ISBN 978-1466261006, p. 14

[99] Ibid.

[100] WARE, Mike. *Prussian Blue: Artists' Pigment and Chemists' Sponge*. Journal of Chemical Education 85, no. 5 (2008): p. 612 - 620. Available from https://doi.org/10.1021/ED085P612, p. 615

[101] Ibid., p. 616

[102] Ibid.

ferricyanide; after the exposure process, the excess chemicals were washed off in a simple water bath.[103]

Other sources, however, claim that the two chemicals were never actually mixed by Herschel, but rather that the image was first soaked in ammonium ferric citrate and dried, then exposed for ¾ of the time that is used in modern cyanotype processes.[104] Only then, was a 2% solution of potassium ferricyanide either poured over the image, or used as a bath for the immersion of the image. This method is best used for negatives that contain a lot of shadows and dark spots, as the images made with Herschel‘s original technique tend to have a wide tonal range and striking colours.[105] However, this method is not especially stable since the colours may easily be washed away from the image.[106]

As discussed in the introduction, the return to ancient crafts and historical practices is a phenomenon that can be observed today, and many artists are rediscovering the knowledge of alternative photographic processes. The cyanotype is one of many resurgent forms of media that is gaining in popularity. This may be due to the wide range of materials that can be used as a printing surface, which includes paper, stone, metal, fabric, and even glass.[107] Cyanotypes can easily be created at home, all that is needed is the two chemicals described above: ammonium ferric citrate (also

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[103] Ibid.

[104] MRHAR, Peter. *Cyanotype: Historical and Alternative Photography*. Self-published, 2013. ASIN B00G0TSSMC, p. 63

[105] Ibid.

[106] Ibid.

[107] Ibid., p. 8

called ammonium iron(III) citrate (C6H8O7 xFe3+ yNH3)), and potassium ferricyanide (also known as potassium hexacyanoferrate(III) (K3Fe(CN)6)).[108] Additional requirements for the cyanotype process include an image carrier (paper, fabric, etc.), a negative for printing photographs or a few objects for creating photograms, a printing frame or a sheet of glass, access to sunlight or a strong UV lamp, and water to wash out the excess chemicals.[109]

Peter Mrhar describes the practical process as follows: *"The cyanotype solution is applied to paper, which is then dried thoroughly. On this light-sensitive carrier, objects or negative film are placed. Under UV light, objects or negative film block part of the light, while on the exposed, uncovered part, the chemical composition of the light-sensitive emulsion changes. When a photograph is developed in ordinary water, the unexposed iron compounds are washed away from the photographs, while the newly-formed, water-insoluble iron ferricyanide, with its characteristic blue colour, remains on the image carrier material."* [110] Additional changes in the final outcome of the colour can also be made, including varying the amounts of light applied to the image carrier, or changing the image after printing by using whitening agents such as ammonia or washing soda.[111]

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[108] Ibid.

[109] Ibid.

[110] Ibid.

[111] Ibid., p. 84

Commercial use of the cyanotype process only truly took off in earnest with the production of blueprints.[112] This was also the only form in which cyanotypes experienced popular commercial use—most notably by architects and similar schematically technical professions—because this process provided a quick and easy solution for copying designs and schematics.[113]

Artistically, cyanotypes were a novel triviality, and they did not reach a higher status than that until the publication of Anna Atkins' *Photographs of British Algae*[114], a compilation of cyanotypes showcasing the vast field of algae and seaweeds native to the British Isles. Her treatise was the first ever book to contain solely photographic images,[115] which opened the way for a whole new genre of visual literature. Botanists around the world started using the cyanotype process and it gained a certain popularity in this area of expertise shortly after its discovery[116], as further discussed in 3.1.

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[112] WARE, Mike. *Cyanomicon - History, Science and Art of Cyanotype*. (Online) OCLC 1044748730. 2020 (accessed 03.2022) Available from https://www.mikeware.co.uk/downloads/Cyanomicon.pdf, p. 17

[113] Ibid., p. 114

[114] ATKINS, Anna. *Photographs of British Algae: Cyanotype Impressions (Sir John Herschel's Copy)*. Göttingen, Germany: Gerhard Steidl Druckerei und Verlag, 2022. ISBN 9783958295100

[115] WARE, Mike. *Prussian Blue: Artists' Pigment and Chemists' Sponge*. Journal of Chemical Education 85, no. 5 (2008): p. 612 - 620. Available from https://doi.org/10.1021/ED085P612, p. 616

[116] WARE, Mike. *Cyanomicon - History, Science and Art of Cyanotype*. (Online) OCLC 1044748730. 2020 (accessed 03.2022) Available from https://www.mikeware.co.uk/downloads/Cyanomicon.pdf, p. 12

2.2 Anthotypes

In 1839, three years before his ground-breaking discovery of the cyanotype, Herschel began experimenting with other light sensitive materials, specifically inks made from the juices of flowers and other plants that he grew in his own garden.[117] It was during this time of initial experimentation that he accidentally discovered the cyanotype process.[118]

Figure 4: “Anthotype #4” by Sir John Herschel, made from red doubler stock. Photograph from 1839 entitled “The Royal Prisoner”, Copyright to Harry Ransom Humanities Research Center, The University of Texas at Austin

[117] Ibid., p. 44

[118] WARE, Mike. *Prussian Blue: Artists' Pigment and Chemists' Sponge*. Journal of Chemical Education 85, no. 5 (2008): p. 612 - 620. Available from https://doi.org/10.1021/ED085P612, p. 615

Anthotypes (Greek: anthos = flower), sometimes called Phytotypes (Greek: phythos = plant)[119] are made by coating paper in vegetable, fruit, or flower juices, which have to contain some kind of natural pigment to create a colour coating. On this paper, one would then arrange either objects or a positive of a photograph, ensuring that it does not move while exposing it to direct sunlight.[120] The exposed parts of the image are bleached by sunlight, while the covered areas remain approximately the same colour. This process, however, requires a long exposure period that can last anywhere from several days to several weeks because of the varying light sensitivities of the materials used. Additionally, there is no way to truly fix the image transferred onto paper; the only way to make sure the image stays unchanged is to keep it in darkness, taking it out for viewing for only very brief periods of time.

Anthotypes unfortunately do not represent a large part of the history of photographic art, with very few records of artists or scientists using this method in their work. Mary Somerville, as discussed in 3.3, is, next to Herschel, has the best documented account of anthotype-related experiments; other lesser-known mentions of practical investigation based on this alternative process include Theodor Freiherr von Grotthuss[121], who, in 1817, established the Grotthuss law of photochemical

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[119] WARE, Mike. *Cyanomicon - History, Science and Art of Cyanotype*. (Online) OCLC 1044748730. 2020 (accessed 03.2022) Available from https://www.mikeware.co.uk/downloads/Cyanomicon.pdf, p. 44

[120] Ibid.

[121] WIKIPEDIA. ‘‘Theodor Grotthuss’’. (Online) Last edited 12.07.21 (Accessed 08.04.22) Available from https://en.wikipedia.org/wiki/Theodor_Grotthuss

absorption[122], after conducting experiments wherein he ‘‘*placed dyestuffs behind coloured glass and discovered that they fade only by the action of those colour light rays that they absorb, the complementary colours, but are preserved by the rays of their own colour, which they reflect.*’’ [123]

Robert Hunt, a librarian and record keeper, as well as a professor of mechanical engineering in London, was also one of the founders of the London Photographic Society and experimented with organic and inorganic photosensitive substances.[124] The study that contributed most to the anthotype process was *Researches on Light: an Examination of All the Phenomena Connected with the Chemical and Molecular Changes Produced by the Influence of the Solar Rays (1844)*.[125]

A French professor of chemistry and member of the Royal Society in London and the Academie des Sciences in Paris, Michel Eugène Chevreul carried out many experiments on the art of dyeing.[126] He was particularly interested in the influence of elements on the permanence of dyes on fabric, and also intently analysed *“how oxygen in the air and moisture affects decomposition of colours when they are*

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[122] WIKIPEDIA. ‘‘Photoelectrochemical Process’’. (Online) Last edited 13.10.21 (Accessed 08.04.22) Available from https://en.wikipedia.org/wiki/Photoelectrochemical_process#Grotthuss–Draper_law Grotthuss-Draper Law: *“The Grotthuss–Draper law (also called the Principle of Photochemical Activation) states that only that light which is absorbed by a system can bring about a photochemical change.”*

[123] FABBRI, Malin. *Anthotypes: Explore the Darkroom in Your Garden and Make Photographs Using Plants*. Stockholm, Sweden: Malin Fabbri, AlternativePhotography.com, 2012. ISBN 978-1466261006, p. 13

[124] Ibid.

[125] HUNT, Robert. *Researches on Light; an Examination of All the Phenomena Connected with the Chemical and Molecular Changes Produced by the Influence of the Solar Rays*. 1844. Charleston, SC, USA: Nabu Press, 2011. ISBN 9781173649708

[126] FABBRI, Malin. *Anthotypes: Explore the Darkroom in Your Garden and Make Photographs Using Plants*. Stockholm, Sweden: Malin Fabbri, AlternativePhotography.com, 2012. ISBN 978-1466261006, p. 14

exposed to light." [127] His research on colour contrast was issued, amongst others, in a document titled *The Principles of Harmony and Contrast of Colours*[128], which was originally published in French in 1839 and translated into English 1854.[129]

[127] Ibid.

[128] CHEVREUL, Michel Eugène and MARTEL, Charles (Translator). *The Principles of Harmony and Contrast of Colours and Their Application to the Arts*. 1854. London, UK: Longman, Brown, Green, and Longmans, 1855. (online) Available from https://archive.org/details/principlesharmo00martgoog/page/n4/mode/2up (Accessed 12.04.22)

[129] FABBRI, Malin. *Anthotypes: Explore the Darkroom in Your Garden and Make Photographs Using Plants*. Stockholm, Sweden: Malin Fabbri, AlternativePhotography.com, 2012. ISBN 978-1466261006, p. 14

3. Artists Working in the Field

The following artists that will be elaborated on in this chapter are a combination of pioneering artists and early photographers, as well as contemporary artists that are actively publishing new work and exhibiting various projects. This will showcase the vast influence of natural and artificial pigments that are mirrored in the practice of photographic art over the course of history as well as serve as a basis for this very specific and particular niche of alternative photographic processes. While the search for artists using natural colour and connected processes is not an impossible one, there is very little extant information on this rarefied subject that has survived over the years to be documented in modern history books.

3.1 Anna Atkins

Much as the narrative of cyanotypes forms a branch of the history of the pigment Prussian Blue, as discussed in 1.2.3, the biography and scientific achievements of this particular artist is a branch of the history of cyanotypes, as seen in 2.3. The English botanist and photographer, Anna Atkins (best known for her early use of photography for scientific purposes) was born with the maiden name, Children, in Kent, in the United Kingdom in 1799 and died in 1871 in the same county in which she was born.[130] Her father, John George Children,was a well-known scientist whose wife passed away shortly after Anna was born, which is likely why the relationship between father and daughter is reported to have been a close one.[131] In 1835, Anna

[130] BRITANNICA. ‘‘Anna Atkins’’. (Online) Last updated 12.03.22 (Accessed 08.04.22) Available from https://www.britannica.com/biography/Anna-Atkins

[131] WARE, Mike. *Cyanomicon - History, Science and Art of Cyanotype*. (Online) OCLC 1044748730. 2020 (accessed 03.2022) Available from https://www.mikeware.co.uk/downloads/Cyanomicon.pdf, p. 135-136

married a close friend of her fathers, John Pelly Atkins, and they enjoyed a London-based life of close scientific collaboration.[132] Her father was also the one who *"(...) brought (Anna) into touch with most of the tight-knit British scientific community of the early part of the nineteenth century"* [133] by collaborating with her, using her illustrations in a translation he wrote about the classification of sea shells.[134] This close relationship is visible even past Mrs. Atkins' lifetime; her gravestone even includes the fact that she was John Children's daughter, which, in comparison to mentioning her husband's name, is rather unconventional.[135]

Anna Atkins' first account of documenting endemic algae using the cyanotype process can be found as early as 1843, wherein she writes; *"I have lately taken in hand a rather lengthy performance, encouraged by my father's opinion that it will be useful- it is the taking Photographical impressions of all (that I can procure) of the British Algre and confervae, many of which are so minute that accurate drawings of them are very difficult to make."* [136] She self-published her photographic book *Photographs of British Algae: Cyanotype Impressions*[137] in 1843; the original introduction states the reason by which she was inspired her to create cyanotypes of

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[132] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 53

[133] Ibid.

[134] WARE, Mike. *Cyanomicon - History, Science and Art of Cyanotype*. (Online) OCLC 1044748730. 2020 (accessed 03.2022) Available from https://www.mikeware.co.uk/downloads/Cyanomicon.pdf, p. 136

[135] SCHAAF, *Larry J. Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 34, fig.3

[136] Ibid., p. 37

[137] ATKINS, Anna. *Photographs of British Algae: Cyanotype Impressions (Sir John Herschel's Copy)*. Göttingen, Germany: Gerhard Steidl Druckerei und Verlag, 2022. ISBN 9783958295100

algae, namely that the details of algae and confervae are so miniscule at times that illustrations are a near-to-impossible task, while the cyanotype process posed a perfect medium for the joint role of scientist and photographer.[138] Atkins chose the algae she depicted based on William Harvey's *A Manual of British Algae* (1841)[139], an unillustrated manual on endemic algae species to which her own publication was intended to be a companion.[140] Mrs. Atkins published her book in several parts, the first being issued in October 1843; afterward she continued to produce more cyanotypes, completing the total publication in 1853.[141] It is not exactly known how many copies of *British Algae* were produced, but fourteen replicas are known to survive to this day, with an additional three sets that are substantial enough to suggest that once, there must have been at least this amount of additional copies.[142] Altogether, Anna Atkins produced over six thousand cyanotype photograms of algae, as well as several hundred pieces depicting ferns and other plants, feathers and lace. There is a hopeful optimism within the pigment making and alternative photography community that this number will continue to grow, as many copies and prints have been found since the initial release of Larry J. Schaaf's *Sun Gardens*.[143] The

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[138] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 38: "…*the difficulty of making accurate drawings of objects as minute as many of the Algre and Confervae, has induced me to avail myself of Sir John Herschel's beautiful process of Cyanotype, to obtain impressions of the plants themselves, which I have much pleasure in offering to my botanical friends."* (From Anna Atkins, *Photographs of British Algae: Cyanotype Impressions*, Introduction)

[139] William Harvey (1841): *A Manual of British Algae*

[140] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 38

[141] Ibid., p. 37

[142] Ibid., p. 38

[143] Ibid.

publications may, on first examination, seem chaotic, but then, as now, this is often merely a symptom of amateur self-publishing and while indicative of a lack of print publication knowledge, in no way impugns or diminishes the excellent quality of the work contained within those pages. Additionally, in the 19th century, it was common practice to purchase a publication wrapped in paper and then have it bound to match the other books in the owner's library.[144] Hence, the bindings of the various specimens largely differed as did the sequence of the different cyanotypes.[145]

For all that Mrs. Atkins managed to accomplish on her own, without the help of publishers and editors, she was not a solitary worker in every aspect of her career. Many of her works feature collaborations with Anne Dixon (née Austen) born in Kent in 1799.[146] Anne's mother died when she was only twelve years old, while her father served in the military and spent most of his time in Portugal; for this reason, Anne, herself a second cousin of the famous writer Jane Austen, although the families were not in close contact, was mostly brought up by her father's dear friend, John George Children.[147] Anne married a vicar, Henry Dixon, who had been known to both John George Children and John Pelly Atkins for quite some time, which made it possible for the three families to become a small, tight-knit community.[148] Anne Dixon was not

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[144] Ibid., p. 39

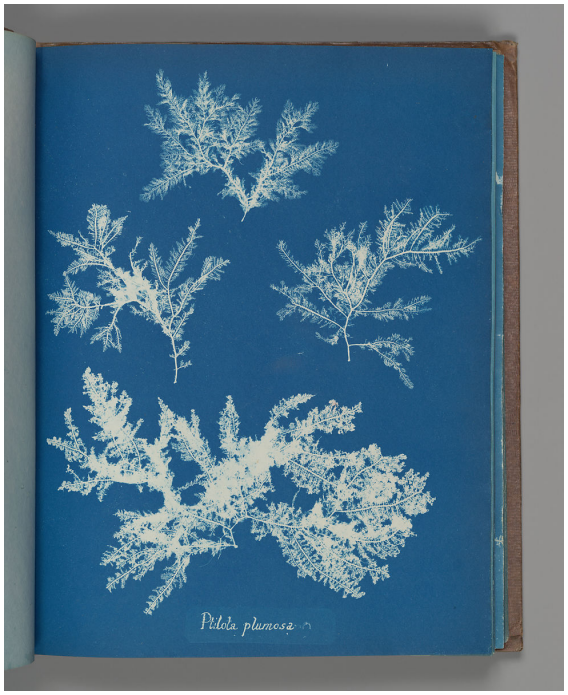
[145] Ibid., p. 39, Anna Atkins in a letter to Anne Bliss (1851): *"Finding I could send this volume out entire, and being conceited enough to think it probable the possessors of the work may put it into some sort of binding when it is finished, I have not had it stitched up at all - as I found on taking a copy to pieces to send to the binder that it was desirable to avoid its being sewn twice."*

[146] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 76

[147] Ibid.

[148] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkin*s. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 76

only a close friend and (for all intents and purposes) sister of Anna Atkins, she was also her years-long work partner. After the substantive bulk of *British Algae* had been produced, Atkins became associated with some of history's finest photograms, and it will never be entirely clear whether or not some of the later found prints were, in fact, produced by Anna Atkins, Anne Dixon, or both in collaboration (which is likely the most plausible explanation).[149]



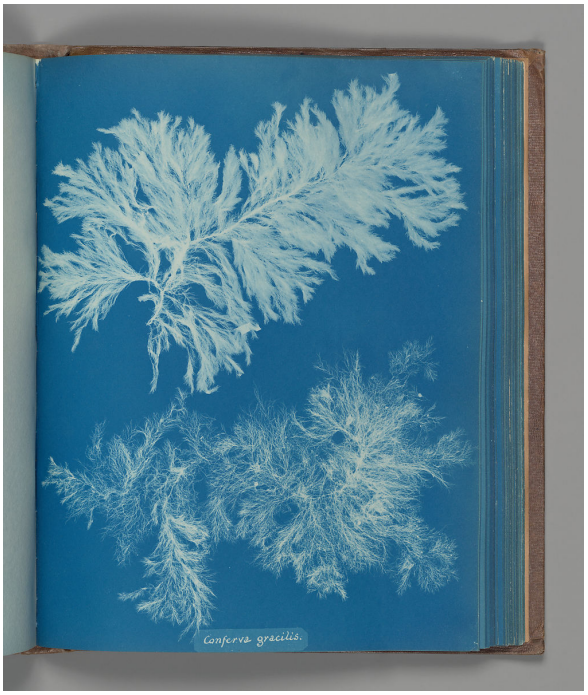


Figure 5; Figure 6: Two examples from Anna Atkins' *Photographs of British Algae: Cyanotype Impressions*. 1843 - 1853. Gilman Collection, Purchase, The Horace W. Goldsmith Foundation Gift, through Joyce and Robert Menschel, 2005

Anna Atkins comprises an important part of the history of photography first and foremost because, upon publishing *Photographs of British Algae: Cyanotype Impressions*,[150] she was the first ever person to publish a book containing only

[149] Ibid., p. 77

[150] ATKINS, Anna. *Photographs of British Algae: Cyanotype Impressions (Sir John Herschel's Copy)*. Göttingen, Germany: Gerhard Steidl Druckerei und Verlag, 2022. ISBN 9783958295100

photographic images that, at the same time, served as scientific studies of endemic algae species, which, in turn, cemented her importance in the scientific world.[151] In 1839, Talbot wrote in a letter to Herschel: *"The enclosed scrap will illustrate what I call 'every man his own printer and publisher' - to enable poor authors to make facsimiles of their own handwriting."* [152] But to everyone's surprise, and to the delight of feminist history, that first ''every man'' was not a man after all.[153]

Atkins' *British Algae* predates any of Talbot's publications by several months, and these have long been thought to be the first publications in book form that were printed using no other means of information than photography, discarding conventional methods of illustration and typesetting.[154] It is, therefore, easy to see that women's voices tend to get lost, especially in the fields of chemistry and science; few people are able to name additional female scientists other than someone of transcendent fame like Marie Curie.[155] For this reason, it is crucial to note that Anna Atkins is considered the first female photographer, as well as an important voice in the history of scientific discoveries and botanical documentation.[156]

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[151] Peter Mrhar, *Cyanotype: Historical and Alternative Photography*, p. 8

[152] De Montfort University Leicester. „The Correspondence of William Henry Fox Talbot". (Online) Last updated 21.03.10 (Accessed 08.04.20) Available from http://foxtalbot.dmu.ac.uk/letters/transcriptDocnum.php?docnum=3843

[153] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 37

[154] Ibid.

[155] BRITANNICA. „Marie Curie". (Online) Last updated 17.02.22 (Accessed 08.04.22) Available from https://www.britannica.com/biography/Marie-Curie

[156] FARBER, Richard. *Historic Photographic Processes - A Guide to Creating Handmade Photographic Images*. New York, USA: Allworth Press, 1998. ISBN 1-880559-93-5, p. 59

3.2 Elizabeth Fulhame

Little is known about Elizabeth Fulhame's personal life, neither the dates of her birth or death, nor her maiden name are matters of public record. What is known is that she was probably Scottish, although that might simply be a consequence of her marriage to a physician of the same nationality, Thomas Fulhame, who absolved his chemistry studies at the University of Edinburgh.[157] In 1780, Mrs. Fulhame became interested in photochemical reactions, namely in the process of making cloths of gold and silver through the reaction formed by light on metallic salts.[158]

In 1794, fifty years before Daguerre's and Talbot's announcements, Elizabeth Fulhame published *An Essay on Combustion; with a View to a New Art of Dying and Painting, wherein the Phlogistic and Antiphlogistic Hypotheses Are Proved Erroneous* [159], wherein she described her experiments and studies using the wet process for metal reduction, as well as the results of how metallic salts contained in silk react to being soaked in chloride of gold and nitrate of silver solutions respectively, and how the exposure of these to sunlight causes a photochemical reaction, leaving behind cloths of gold and silver.[160] On the first page, Mrs. Fulhame elaborates on how her

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[157] Sotheby's Institute of Art. "The Woman Behind Photography". (Online) Date and author unknown. (Accessed 08.04.20) Available from https://www.sothebysinstitute.com/news-and-events/news/the-woman-behind-photography

[158] Ibid.

[159] FULHAME, Elizabeth. *An Essay on Combustion; with a View to a New Art of Dying and Painting, wherein the Phlogistic and Antiphlogistic Hypotheses Are Proved Erroneous*. Philadelphia, USA: James Humphrey's, 1810. (Online) Available from: https://digital.library.upenn.edu/women/fulhame/combustion/combustion.html

[160] EDER, Josef Maria. *History of Photography*. New York, USA: Dover Publications, 1978. ISBN 0-486-23586-6, p. 116; *"(…) Mrs. Fulhame describes, along with a number of other experiments, the different media to be used in order to reduce metals by the wet process and how the salts contained in silk material after having been soaked in a solution of chloride of gold or nitrate of silver are reduced to metal in light."*

husband and some friends discussed the possibility of making cloths of gold and silver but decided that any successful results were improbable.[161] This prompted her to conduct her own experiments (more than she believed were strictly necessary), which resulted in a significant amount of successful results.[162]

In the eighth chapter of her report, Mrs. Fulhame deals with the reduction of metal by light, producing two crucial observations:[163] first, she points out that water alone cannot reduce the gold and silver salts, however, light on its own is indeed capable of this effect; second, the combination of water and light inevitably produces this effect.[164] She demonstrated and reproduced these findings with the experiments she conducted, dipping pieces of silk in solutions of either chloride of gold or nitrate of silver and exposing the material to sunlight while it was soaked in water.[165] The material soaked in the gold solution first turned a pale green, followed then by a purple colour, which finally turned into a crust of reduced gold.[166] The material soaked in the silver solution, on the other hand, first turned a reddish-brown and then a greyish-black.[167] The following conclusions were drawn by Mrs. Fulhame about her own experiments; *"That water is absolutely necessary to the reduction of metals by*

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[161] FULHAME, Elizabeth. *An Essay on Combustion; with a View to a New Art of Dying and Painting, wherein the Phlogistic and Antiphlogistic Hypotheses Are Proved Erroneous*. Philadelphia, USA: James Humphrey's, 1810. (Online) Available from: https://digital.library.upenn.edu/women/fulhame/combustion/combustion.html, p. 10

[162] Ibid.

[163] EDER, Josef Maria. *History of Photography*. New York, USA: Dover Publications, 1978. ISBN 0-486-23586-6, p. 117

[164] Ibid.

[165] Ibid.

[166] Ibid.

[167] Ibid.

light (..) that light acts in this reduction just like hydrogen, sulphur, and carbon (…) that light could accomplish this only through the decomposition of water." [168] With these conclusions, her research predates any historical publications on photosensitive processes involving gold and, specifically, silver, and functions as the principal body of work for the further development of photography.

The importance of her work cannot be overstated. In 1810, the year her book was republished in the German language, she was appointed a corresponding member of the Chemical Society of Philadelphia.[169] This was another important milestone for feminist history. Sadly it is, again, an accomplishment that is often overlooked, and Mrs. Fulhame's work is usually not mentioned in textbooks and other theoretical documents.[170]

3.3 Mary Somerville

Mrs. Mary Somerville (née Fairfax), a very underrated female scientist of the Victorian era, was born in 1780 in Jedburgh, Scotland.[171] Her second marriage to Dr. William Somerville resulted in four children in addition to the four from her previous

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[168] FULHAME, Elizabeth. *An Essay on Combustion; with a View to a New Art of Dying and Painting, wherein the Phlogistic and Antiphlogistic Hypotheses Are Proved Erroneou*s. Philadelphia, USA: James Humphrey's, 1810. (Online) Available from: https://digital.library.upenn.edu/women/fulhame/combustion/combustion.html

[169] Sotheby's Institute of Art. ''The Woman Behind Photography''. (Online) Date and author unknown. (Accessed 08.04.20) Available from https://www.sothebysinstitute.com/news-and-events/news/the-woman-behind-photography

[170] FULHAME, Elizabeth. *An Essay on Combustion; with a View to a New Art of Dying and Painting, wherein the Phlogistic and Antiphlogistic Hypotheses Are Proved Erroneous*. Philadelphia, USA: James Humphrey's, 1810. (Online) Available from: https://digital.library.upenn.edu/women/fulhame/combustion/combustion.html, p. 5

[171] FABBRI, Malin. *Anthotypes: Explore the Darkroom in Your Garden and Make Photographs Using Plants*. Stockholm, Sweden: Malin Fabbri, AlternativePhotography.com, 2012. ISBN 978-1466261006, p. 12

marriage to a Captain who passed away not long after the birth of their fourth child.[172] Her interest in philosophy, astronomy, and mathematics drove her to work on her experiments involving magnetism, and made it possible to publish her work, a translation of Pierre-Simon Laplace's *Traité de Mécanique Céleste*, *The Mechanism of the Heavens,*[173] which was partly responsible for her and Caroline Herschel[174] (one of Frederick William Herschel's sisters) to become the first female members of the Royal Astronomical Society.[175]

Because Mrs. Somerville was a woman living under the patriarchally constrictive publishing policies of Victorian English society, she was unable to publish her papers herself; instead, they were published through a letter she sent to John Herschel, under the title *"On the Action of the Rays of the Spectrum on Vegetable Juices. Extract of a Letter from Mrs. M Somerville to Sir J.F.W. Herschel, Bart., dated Rome, September 20, 1845. Communicated by Sir J. Herschel. Received November 6, - Read November 27, 1845".*[176] The contents of her letter described, in much detail, the effect of the ''action of rays'' on vegetable juices using the spectre of rays to determine any changes and effects that each of them might have on the presented

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[172] Ibid.

[173] LAPLACE, Pierre-Simon. *Mechanism of the Heavens* (Cambridge Library Collection - Physical Sciences) (M. Somerville, Trans.). Cambridge, UK: Cambridge University Press, 2009. ISBN 9780511693137

[174] BRITANNICA. ''Caroline Lucretia Herschel''. (Online) Last updated 12.03.22 (Accessed 08.04.22) Available from https://www.britannica.com/biography/Caroline-Lucretia-Herschel

[175] FABBRI, Malin. *Anthotypes: Explore the Darkroom in Your Garden and Make Photographs Using Plants*. Stockholm, Sweden: Malin Fabbri, AlternativePhotography.com, 2012. ISBN 978-1466261006, p. 12

[176] Ibid., p. 13, Example text of the report: *"On the juice of Plumbago auriculata the lavender and violet rays produced a pale brown image; the indigo rays had no effect, while all the rest of the image under the mean and least refrangible rays was blue and indigo."*

plant juices; she would, variously, add modifiers like salts, metals, acids, or alkaline compounds to understand how it might affect her experimental studies.[177]

An excerpt of Mrs. Somerville‘s letter to John Herschel shows the extent to which she went to fully understand the effect of the whole light spectrum on different light-sensitive plant juices as well as experimenting with different modification techniques; the letter reads as follows: *“Paper washed with the juice of beet-root in distilled water assumed a fine rose-colour, on which a figure was bleached by the spectrum, wide and rounded in the yellow, but tapering upwards: after another wash, a dark crimson image was formed in its centre reaching to the blue, with a still darker spot under the yellow. The red rays had no effect, below which at the usual distance two indistinct spots appeared. A drop of sulphuric acid in the juice changed the tint of the paper to a purple colour, on which, after various alternations of bleaching and darkening, the spectrum im pressed a dark figure, broad and rounded on the yellow, and tapering to the blue, beyond which there was scarcely any action (fig. 8.). The whole was surrounded by a broad pale border, stretching in a neck far beyond the red, with an indefinite dark line in its centre.”* [178]

It is clearly apparent that most, if not all, of the early photographic pioneers were not only active in the fields of the visual arts, but were, first and foremost, scientists conducting experiments on theoretical questions involving organic and inorganic

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[177] FABBRI, Malin. *Anthotypes: Explore the Darkroom in Your Garden and Make Photographs Using Plants*. Stockholm, Sweden: Malin Fabbri, AlternativePhotography.com, 2012. ISBN 978-1466261006, p. 13

[178] SOMERVILLE, Mary. “On the Action of the Rays of the Spectrum on Vegetable Juices. Extract of a Letter from Mrs. M Somerville to Sir J.F.W. Herschel, Bart., dated Rome, September 20, 1845. Communicated by Sir J. Herschel. Received November 6, - Read November 27, 1845”. London, UK: Philosophical Transactions of the Royal Society of London, vol. 136, 1846, p. 111 - 120. (accessed 07.04.2022) Available from http://www.jstor.org/stable/108310

compounds as well as the effects that light and photosensitive reactions can have on the same. It is interesting to note the connection between many of the scientific pioneers of the 19th and 20th century, as can perhaps be best seen in the example of the fifth Solvay Conference[179] held in Brussels in 1927; this was the first and only time that such a number of great geniuses and Nobel Prize winners were so immediately collocated, including Paul Dirac, Wolfgang Pauli, Erwin Schrödinger, Marie Curie, and Albert Einstein, the latter of which were overseeing the committee along with Hendrik Lorentz.[180] Additionally, Mary Somerville's memoirs mention John Herschel (who was a dear friend to the Somervilles) in several accounts,[181] as well as the British admiral and explorer of the arctic, Sir William Edward Parry, for whose three-year-long journey through the Arctic she made *"a large quantity"* [182] of orange marmalade.After Parry's return, Somerville learned that an island had been named after her.[183]

3.4 Susanne Kriemann

When speaking of contemporary artists fusing both photography and the extraction and use of organically derived pigments, no discussion can be considered complete

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[179] WIKIPEDIA. ''Solvay Conference''. (Online) Last edited 25.02.22 (Accessed 08.04.22) Available from https://en.wikipedia.org/wiki/Solvay_Conference

[180] LABATUT, Benjamin. *When We Cease to Understand the World*. London, UK: Pushkin Press, 2020. (EBook) ISBN 9781681375670. Available from https://1lib.cz/book/17047811/7d4fea, p. 144

[181] SOMERVILLE, Mary. *Personal Recollections, from Early Life to Old Age, of Mary Somerville*. Salt Lake City, UT, USA: Project Gutenberg Literary Archive Foundation, 8.01.2009. EBook number: 27747. Available from http://www.gutenberg.org/2/7/7/4/27747/, p. 59

[182] Ibid., p. 60: *"On this occasion I put in practice my lessons in cookery by making a large quantity of orange marmalade for the voyage. When, after three years, the ships returned, we were informed that the name of Somerville had been given to an island so far to the north that it was all but perpetually covered with ice and snow."*

[183] Ibid.

without mentioning Susanne Kriemann. Born in Germany in 1972, she now lives and works in Berlin while also teaching in Karlsruhe.[184] Kriemann sees the world as an analogue archive for human-caused actions, processes, and developments, which has led her to be primarily occupied with subjects such as radioactivity, mining, and archaeology with a prevalent focus on ecology, while at the same time recognising polluted environments as vast photosensitive arrays.[185] She extracts pigments from the investigated matter and uses them to print her photos utilising either the photogravure or the screenprinting method.[186]

Susanne Kriemann makes radioactivity a physical compound in her work by extracting pigments from radioactive plants and using them in her printing processes, as she did in her exhibition *Reconsidering Photography: Underbrush*[187], wherein she put two of her works into a visual discussion with around forty works from the Photography and Media collection at MK&G, establishing a connection to the history of pigment extraction and printing techniques.[188]

Another example of Kriemann's unusual use of pigment extraction is *Forest, frst, t like teamwork*[189]; an artistic intervention on the subject of deforestation, featuring a

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[184] KRIEMANN, Susanne. ''CV''. (Online) 2021. (Accessed 08.04.20) Available from http://www.susannekriemann.info

[185] Ibid.

[186] Ibid.

[187] MKG Hamburg. ''Susanne Kriemann - Reconsidering Photography: Underbrush''. (Online) Date and author unknown. (Accessed 08.04.20) Available from https://www.mkg-hamburg.de/en/exhibitions/archive/2021/susanne-kriemann.html

[188] Ibid.

[189] KRIEMANN, Susanne. ''Forest, frst, t like teamwork''. (Online) Date and author unknown. (Accessed 08.04.20) Available from http://www.susannekriemann.info/news/forest-frst-t-like-teamwork/

visual essay processed by means of screen printing, using a pigment extracted from discarded Ikea furniture.[190] In 2021, Kriemann published *Mngrv (polymersday series)*[191], an archival series of diptychs depicting mangrove forests tangled in plastics that she photographed in Southeast Asia; the final prints use debris and oil collected from where the photographs were taken and critically explore the blurring boundaries between nature and culture that are created through climate change and environmental pollution.[192]

Kriemann‘s working process is an interesting one because she uses pigments she extracts from the location of the phenomenon she wishes to represent; this sense of ‘ ‘‘hyperlocality’’ and its application in the arts is one that is rarely observable, many times reserved for practices outside of the arts spectrum, such as beer brewing and fermentation.[193] The term *hyperlocal* is used to describe practices and relationships involving a very small community, neighbourhood or geographical place.[194] In her case, Susanne Kriemann makes use of a particular place, scene, or object and physically incorporates it in her work, using ancient processes of pigment extraction as well as printing methods. In this way, the artist creates a piece that not only

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[190] Ibid.

[191] GIBCA. Susanne Kriemann: ‘‘Mngrv (polymersday series)’’, 2021. (Online) Date and author unknown. (Accessed 08.04.20) Available from https://www.gibca.se/en/gibca/gibca2021/artists/susanne-kriemann/

[192] Ibid.

[193] BAUDAR, Pascal. *The Wildcrafting Brewer*. Vermont, USA: Chelsea Green Publishing, 2018. ISBN 9781603587181, p. 16

[194] DICTIONARY. ‘‘Hyperlocal’’. (Online) 2022 (Accessed 08.04.22) Available from https://www.dictionary.com/browse/hyperlocal

thematically criticises environmentally connected issues, but embodies the problem in its visual and physical representation.

3.5 Jan Jedlicka

Jan Jedlicka is a very important Czech artist who has dedicated his work to the exploration of soil-based natural colours that he came across in his home of choice, the Maremma region in Italy; he is not very well-known in the Czech Republic itself however, for which reason his work is included in this thesis.

Jedlicka was born in Prague in 1944 and emigrated to Zurich, Switzerland in 1968, where he lives and works to this day, though he did also return to Prague where he built a second home for himself.[195] Before emigrating, he graduated from Ladislav Cepelak's[196] studio at the Academy of Fine Arts in Prague.[197] Like many people living in Switzerland, he visited the Maremma region in Southern Tuscany in the 1980s. This part of Italy became a constant means of inspiration for him, and he spent most of the decade collecting soil, mineral, clay, and dust samples in nature and along the roads, which served as representations of the land he loved so much.[198] He works with various media, but his pigment paintings do not serve as a depiction of the landscapes wherein he searched for colours; rather, abstract forms and structures

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[195] GHMP. „Jan Jedlička: 20. 5. 2021 - 5. 9. 2021". (Online) Date and author unknown. (Accessed 08.04.20) Available from https://www.ghmp.cz/en/exhibitions/jan-jedlicka/

[196] FineArt.CZ. „Ladislav Čepelák". (Online) Date and author unknown. (Accessed 08.04.20) Available from http://www.fineart.cz/artist_page.aspx?langId=2&artist=5

[197] Kavka Book. „Jedlička Jan". (Online) Date and author unknown. (Accessed 08.04.20) Available from https://www.kavkabook.cz/en/jedlicka-jan

[198] Ibid.

represent the environment in an unusual, more connective way.[199] Like many artists who incorporate natural compounds and elements of scientific research into their work, Jedlicka makes sure that his investigations are understandable, well structured, and properly presented; *"He systematically places the pigments next to one another in the order in which he found them, and this creates a specific representation of the landscape that documents its colour and structure."*[200]

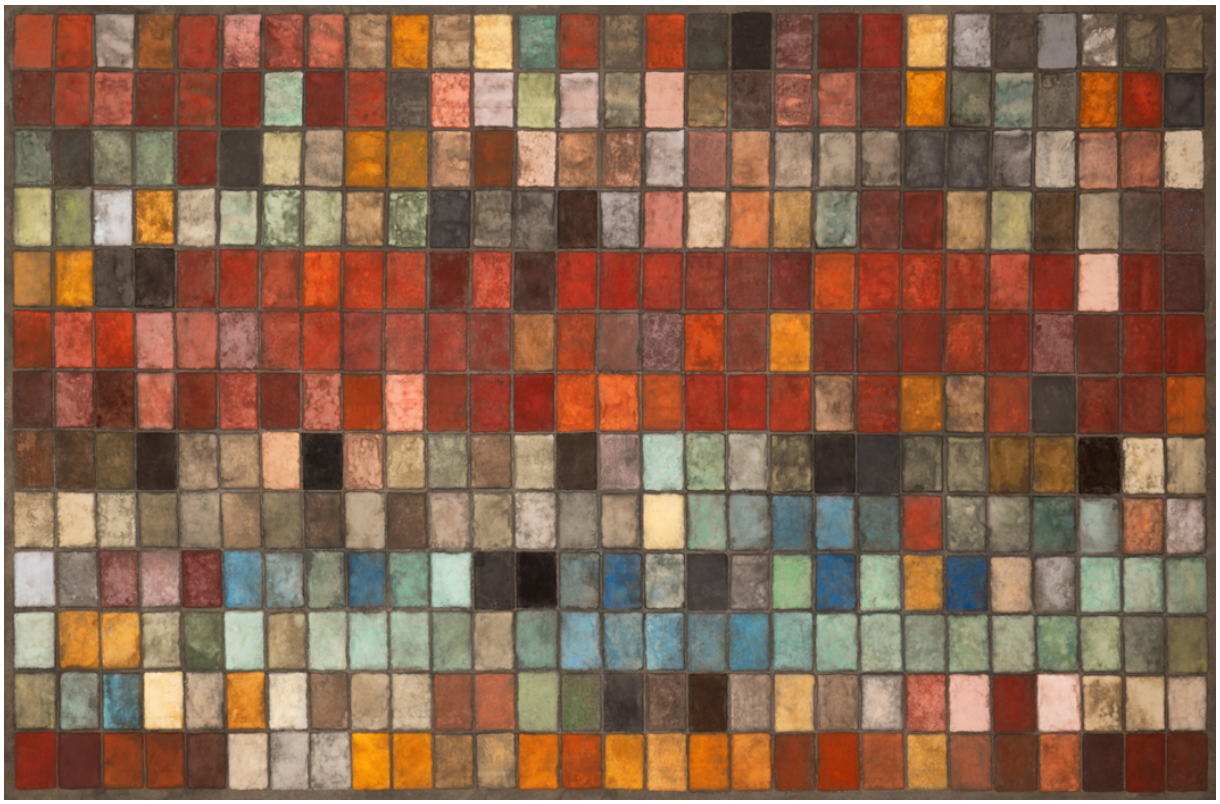

Figure 7: Jan Jedlička, Maremma, 364 colouri, 2019 - 2020

In the 1990s, after having worked with pigments and landscapes gathered in the Maremma region for about a decade, Jedlicka ventured further and conducted investigations on different types of landscapes, including Irish and Welsh soils and

[199] GHMP. "Jan Jedlička: 20. 5. 2021 - 5. 9. 2021". (Online) Date and author unknown. (Accessed 08.04.20) Available from https://www.ghmp.cz/en/exhibitions/jan-jedlicka/

[200] Ibid.

minerals; around the 00s, he decided to return to his birthplace, Prague, and to begin his research of, and practices on, the Czech environment.[201] This extended his line of work from abstract pigment paintings to paintings of buildings and landscapes, photographs, and video pieces representing the places he worked at with various means of visual communication.[202]

Jan Jedlicka‘s work is fascinating because it provides visual, scientific research into the colour-related properties of a single place. Similar to Susanne Kriemann, Jedlicka makes use of the locality of his subject and tries to represent it by incorporating its natural compounds. Unlike Kriemann, however, he works with a less figurative vision, choosing instead to break up the landscape into its single colour compounds, a technique that requires keen visual acuity and considerable technical knowledge to properly locate and identify. His ability to use and incorporate physical components of a place and represent it in an abstract visual language is rarely seen in the execution of this specific method and is a feature especially particular to Jedlicka‘s work.

[201] Ibid.

[202] Ibid.

4. Female Practices, Witchcraft, and Disenchantment: A Societal Evolution

This last chapter aims to connect the historical development of pigment extraction and its female influences with the cultural image of women in the context of witchcraft as well as the societal retreat from magic and spiritualism that followed the advent of industrialization.

Historically, there is and always has been an array of crafts, practices, and knowledge reserved for the female members of society: weaving, sewing, and dyeing as well as the uses of herbal medicine are ancient forms of knowledge that has been passed down from generation to generation, specifically on the female side of the family. These practices have created a foundation for what many women still enjoy doing in their free time even now, namely crafts that involve the hands and the brain at the same time.

This does not mean that male members of society are unable to carry out these tasks, nor that female members of society cannot practice generally ‘‘male’’ craft, but merely suggests that the energy surrounding this subject does, as many things in nature and life tend to do, divides itself into a dichotomy of male and female.[203] This division of the male and female is visible in the ways that ancient pagan religions describing the coming and going of the seasons wherein spring and summer are typically represented by a personification of the female while autumn and winter are represented by the personification of the male, goddesses and gods respectively,

[203] FRAZER, James George. The Golden Bow (Volume 1). New York, USA: The Macmillan Company, 1925. OCLC 499736954, p. 135

which, in many polytheistic religions, assume a position of dominion in some form or another.

Female crafts and practices have undergone a turbulent development influenced by European witch hunts and industrialisation, both of which created a deep gender divide, which still prevails in various forms to this day.[204]

4.1 Historical Female Crafts

Generally speaking, it may be said that female crafts have always had a closer and more intimate connection to nature than those regarded as male; historically male crafts and work occupations include black smiths, builders, knights and similar fighters, some of which, of course, do work with natural compounds, but seem, when compared to crafts like herbalism, healing, knitting or yarn spinning, much less based on bioavailable resources and sustainable processes.

This specialisation of crafts deemed to be feminine can be connected to photographic practices seen in examples from the work of Anna Atkins, a well-regarded, highly respected member of the English botanical community of her day. For though this was a time in which male crafts shifted to the areas of science, law, and similarly important fields, botany was a scientific endeavour wherein women and their work were highly welcome and even encouraged.[205] This is a milestone indicating the beginning of women being able to return to their original practices with

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[204] BRATICH, Jack Z., and BRUSH, Heidi M. “Fabricating Activism: Craft-Work, Popular Culture, Gender.” Utopian Studies, vol. 22, no. 2, 2011, pp. 233–60, https://doi.org/10.5325/utopianstudies.22.2.0233 (Accessed 10 Apr. 2022), p. 235

[205] SCHAAF, Larry J. *Sun Gardens: Cyanotypes by Anna Atkins*. Munich, Germany / London, UK / New York, USA: Prestel Publishing & DelMonico Books, 2018. ISBN 9783791357980, p. 46

a commercial space while also establishing new and innovative scientific approaches.

4.1.1 Present Day Representation of Female Crafts

As mentioned in the introduction, the return of ancient arts, crafts, and practices is a phenomenon that can be observed today; the rising interest in historically important habits and crafts may have possibly been accelerated by the recent lockdowns, but it is a trend that was certainly visible even before the start of the pandemic. Crafts generally perceived as female include traditionally domestic activities: knitting, weaving, crocheting, scrap-booking, or sewing for example .[206] These have been taken up by a young generation of women and popularised through platforms such as Instagram, as well as commercialised through websites like Etsy.com,[207] attracting a new kind of ‘‘craft consumer’’.

Typically female crafts such as knitting or weaving do, in most cases, have an element of nature that creates a connection between the practitioner and the practised subject: knitting or weaving with wool, dyeing the wool with natural colours, spinning naturally derived fibres, or studying plants and their properties for use as medicines.

4.1.2 Fabriculture and Craftivism

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[206] BRATICH, Jack Z., and BRUSH, Heidi M. “Fabricating Activism: Craft-Work, Popular Culture, Gender.” Utopian Studies, vol. 22, no. 2, 2011, pp. 233–60, https://doi.org/10.5325/utopianstudies.22.2.0233 (Accessed 10 Apr. 2022), p. 234

[207] LUCKMAN, Susan. ‘‘The aura of the analogue in a digital age: Women's crafts, creative markets and home-based labour after Etsy’’. (Online) 01.03.13 (Accessed 10.04.20) Available from https://search.informit.org/doi/abs/10.3316/informit.273273712487637

In recent years, the popularity of arts and crafts-based practices, DIY, and homemade goods has been steadily on the rise, both socio-culturally and commercially; younger generations of women especially are finding comfort and joy in learning original, ancient crafts like knitting or dyeing fabrics.[208]

This shift towards a more homemade and craft-oriented consumer culture is one that is both followed and, almost certainly, one that has also been initiated by industrialization and the estrangement of crafts that humans used to have a strong personal connection to. And, with this depersonalisation of final products now fabricated in factories by means of quick and cheap mass production instead of personal, individual acts of creation from an artisan in the space of their studio or home.[209] Industrialisation has, therefore, transformed the art of craft work from that of an artisan‘s guild to one of industrial factory production, stripping from it its tightly knit communal and personal nature, once so vital to, and indicative of, the trade of artisanal wares.[210] In addition to this, the industrial denuding of the craftwork scene created a significant gender gap that only further reinforced the mistreatment of women initiated by the witch trials. Men were, for example, employed in spinning factories and received full financial remuneration, while women were only allowed to work if their money went to a man connected to them.[211]

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[208] BRATICH, Jack Z., and BRUSH, Heidi M. “Fabricating Activism: Craft-Work, Popular Culture, Gender.” Utopian Studies, vol. 22, no. 2, 2011, pp. 233–60, https://doi.org/10.5325/utopianstudies.22.2.0233 (Accessed 10 Apr. 2022), p. 234

[209] Ibid., p. 234

[210] Ibid.

[211] Ibid., p. 235

4.2 Witchcraft and Connected Practices

The term ‘‘witchcraft’’ elicits various attitudes from different people; some meet the concept with a chuckle while others use it with respect and understanding. There are few things in this world that divide and polarise people to the extent that the belief in magic and witchcraft does. Some truly fear those who actively and openly practice rituals, crafts, and traditions connected to ancient pagan religions such as Wicca, either for religious reasons or an inability to grasp the existence of something above themselves.

Practices that are historically connected to the term ‘‘witchcraft’’ include anything tied to herbal knowledge and its practical application, spell casting or word magic, candle magic, etc.,[212] as well as more common occupations like those of midwives and healers. Therefore, many of today’s women’s crafts are historically connected to some form of witchcraft,

4.2.1 The Witch Hunt: A History of Gendercide

One of the most gruesome, direct attacks on women, the European Witch Hunt, remains, to this day, a hushed subject. On this continent alone, it led to an estimated 100,000 trials and 50,000 executions, of which only 25% were men.[213] According to Gibbons (2020), *‘‘Traditional attitudes towards witchcraft began to change in the 14th*

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[212] BUCKLAND, Raymond. *Buckland‘s Complete Book of Witchcraft*. St. Paul, MS, USA: Llewellyn Publications, 1986. ISBN 9780875420509

[213] GIBBONS, Jenny. ‘‘Recent Developments in the Study of The Great European Witch Hunt.’’ Pomegranate: The International Journal of Pagan Studies, 2012, p. 2 - 16. Sheffield, UK: Equinox Publishing. (Accessed 11.04.22) Available from http://www.faculty.umb.edu/gary_zabel/Courses/Phil%20281b/Philosophy%20of%20Magic/Arcana/Witchcraft%20and%20Grimoires/witch_hunt.html

century, at the very end of the Middle Ages. (…) In the 17th century, the Great Hunt passed nearly as suddenly as it had arisen. Trials dropped sharply after 1650 and disappeared completely by the end of the 18th century." [214]

Although, according to the previous statement, witch trials and burnings had largely disappeared from Europe by the end of the 18th century, it should be pointed out that it did and does still linger in some areas, specifically in the country of Ireland where superstition and mystical beliefs survive in common society to this day.[215] One account, ''The Witch Burning at Clonmel'',[216] is especially fascinating. When Bridget Cleary's burnt body was found in her kitchen, her family and neighbours claimed that she had been taken by fairies (or faeries[217]) and that this was in fact the body of a changeling,[218] while the real Bridget remained lost.[219] This was the first of a series of modern accounts of burnings or killings of women connected to mystical and spiritual themes; the one-hundred-year-long reprieve from witch burnings and connected executions proved itself to be temporary one while, at the same time, heralding the dawn of an era of re-enchantment. The return of spiritual and magical practices, as

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[214] Ibid.

[215] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences*. Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 126

[216] GOMME, Laurence ''The Witch-Burning' at Clonmel." Folklore, vol. 6, no. 4, 1895, pp. 373–84, http://www.jstor.org/stable/1253745 Accessed 12.04.22

[217] WIKIPEDIA. ''Fairy'' (Online) Last edited 06.04.22 (Accessed 12.04.22) Available from https://en.wikipedia.org/wiki/Fairy

[218] WIKIPEDIA. ''Changeling'' (Online) Last edited 24.03.22 (Accessed 12.04.22) Available from https://en.wikipedia.org/wiki/Changeling

[219] BOURKE, Angela. "Reading a Woman's Death: Colonial Text and Oral Tradition in Nineteenth-Century Ireland." Feminist Studies, vol. 21, no. 3, 1995, pp. 553 - 586, Available from https://doi.org/10.2307/3178199. (Accessed 10.04.22), p. 553

well as an explosive wave of religious movements, cults, and spiritual ideals that took over the world in the 1960s and 70s during the ‘‘Dawning of the New Age’’,[220] as further discussed at the end of this chapter under 4.4.2.

Within the history of the European witch trials, there are many accounts of ‘‘bad’’ witches and their mischievous actions, such as ruining crops, laming cattle, or cursing people in the village for seemingly no reason.[221] There were, however, ‘‘good’’ witches too: healers, midwives, etc. that[222] were thrust into the narrative of gendercide,[223] a newly risen hatred and fear of female members of society. This did not only result in many deaths that could have been avoided; it also led to a tremendous loss of knowledge that, oftentimes, was passed on bilaterally and then written down by the receiver of the information.[224] Decades-old expertise surrounding plants and their attendant medicinal properties as well as minerals, word magic (spells) and connected practices, traditionally handed down from grandmother to granddaughter, were all silenced in an attempt to purge the world of unchristian values.

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[220] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences.* Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 36

[221] FEDERICI, Silvia. *Caliban and the Witch: Women, the Body and Primitive Accumulation*. London, UK: Penguin Random House, 2021. ISBN 978-0-241-53253-9, p. 224

[222] Ibid., p. 225

[223] GIBBONS, Jenny. ‘‘Recent Developments in the Study of The Great European Witch Hunt.’’ Pomegranate: The International Journal of Pagan Studies, 2012, p. 2 - 16. Sheffield, UK: Equinox Publishing. Available from https://www.faculty.umb.edu/gary_zabel/Courses/Phil%20281b/Philosophy%20of%20Magic/Arcana/Witchcraft%20and%20Grimoires/case_witchhunts.html

[224] FEDERICI, Silvia. *Caliban and the Witch: Women, the Body and Primitive Accumulation*. London, UK: Penguin Random House, 2021. ISBN 978-0-241-53253-9, p. 225

4.3 Disenchantment

Disenchantment, in a socio-cultural context, describes the rationalisation of religion and the consequent decrease of related practices and beliefs. Generally, trust and belief in science is more important in Western civilization than adherence to a religious or spiritual path.[225] In this sense, disenchantment has been happening ever since science entered the world, at least as early as the Enlightenment, but more specifically since industrialisation and the gradual stepping away from Romanticism and nature towards the artificial and the mechanistic.

Consumerism and capitalism have played an indisputably crucial role in the rapid acceleration of disenchantment. As the world population grew exponentially, so too did the need for cheaper and quicker means of production and a means by which to explain the world to its inhabitants in a scientific, rational manner. Magic, religion, and spirituality no longer have a valid place in the world, especially given the ever-accelerating velocity of its constant change.

The term disenchantment, in the context of a society shifting from magical and spiritual beliefs to religious ones and, ultimately, to science is most often associated with Max Weber,[226] who believed that ‘‘modernity meant the death of magic.’’ [227]

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[225] WIKIPEDIA. ‘‘Disenchantment’’. (Online) Last edited 25.04.21 (Accessed 12.04.22) Available from https://en.wikipedia.org/wiki/Disenchantment

[226] BRITANNICA. ‘’Max Weber’’. (Online) Last updated 17.02.22 (Accessed 02.12.21) Available from https://www.britannica.com/biography/Max-Weber-German-sociologist

[227] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences*. Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 154

Weber was, however, strongly influenced by the writings of Frazer,[228] as was Aleister Crowley, who constitutes, as discussed in the last point of this chapter, an important element to the push towards re-enchantment.[229]

4.3.1 From Magic to Religion to Science[230]

As previously mentioned, practices that are today described as part of witchcraft or magic have long been an integral part of society and everyday life; for thousands of years, members of ancient civilizations have used ritualistic and nature-connected means to speed up recoveries, bless their harvests, or give thanks for the arrival of spring, for example.

With the growth of religion and practices supported by the church, magic and witchcraft shifted from being perceived as everyday practices and ‘‘good’’ acts into being seen as something bad, even evil, as Frazer states in 1906: *“As religion grows, magic declines into a black art.”* [231]

As discussed in 2.1, in the example of Anna Atkins, one can observe that, during the 18th and 19th century, women were allowed to return to their ancient and original practices in a socially and commercially acceptable context, all the while retaining

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[228] FRAZER, James George. *The Golden Bow (Volume 1)*. New York, USA: The Macmillan Company, 1925. OCLC 499736954

[229] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences*. Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 153 - 176, Chapter Six, *The Revival of Magick: Aleister Crowley*

[230] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences*. Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 125

[231] FRAZER, James George. *The Golden Bow* (Volume 1). New York, USA: The Macmillan Company, 1925. OCLC 499736954

some distance from by approaching them in a scientific rather than a mystical manner. In that sense, the rise of disenchantment may have helped somewhat to provide a cover for women to go back to their roots and to the more scientific studies of plants, fibres, and colour compounds; on the other hand, this said ‘‘cover’’ may have created a divide between women taking a more theoretical approach on such subjects and those sticking to old practices and sourcing their knowledge by other, non-scientific means.

4.3.2 Re-enchantment: The Return of Ancient and Spiritual Practices

Just as there has been a decline of magical and spiritual practices brought on primarily by the church’s rise to power and its fears surrounding the competition that spiritual and magical practices brought along,[232] a developing re-enchantment of the world has been observed in the last century. As mentioned in 4.1, witch trials had mostly ceased by the end of the 18th century. By the end of the 19th century, however, mystical and magical subjects once again became the cause of a number of women’s deaths, specifically in Ireland wherein accounts of ‘‘changelings’’ (i.e., women getting abducted by fairies/faeries and swapped for a changeling whose body was then found) were by no means uncommon.[233]

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[232] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences.* Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 125

[233] BOURKE, Angela. “Reading a Woman’s Death: Colonial Text and Oral Tradition in Nineteenth-Century Ireland.” Feminist Studies, vol. 21, no. 3, 1995, pp. 553 - 586, Available from https://doi.org/10.2307/3178199. (Accessed 10.04.22), . 553

It might still seem bizarre or even ridiculous to many that some modern, Western people still practice ancient forms of what we call magic as a part of everyday life;[234] for others, however, it forms part of their religious orientation or simply a deeply stated interest in spiritualism and mysticism.

[234] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences.* Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 154

5. Conclusion

The importance of the history and chemical properties of organic as well as inorganic pigments has indisputably created a foundation for the art world that we know today. Without the extensive work and research provided by the early pioneering efforts of alchemists, scientists, painters, photographers and similar practitioners, colours would certainly not be vested with the same significance that they are today.

Not only have colours created symbolism and significance in a cultural context, they have also contributed a great deal to the practical and theoretical development of modern chemistry and, most shockingly, biological weapons and antidotes to potent poisons. The journey one embarks on when uncovering the history of pigments, dyes, and colour extraction is a turbulent one, festooned with intriguing, tangential stories and mind-boggling facts as well as a few amusing dead-ends, which have all contributed to the large body of work that forms the theory, extraction, and application of pigments in various artistic disciplines.[235] The history of such colour-related practices is as old as civilization itself, but the knowledge and theoretical accounts about it are ones that have to be actively sought out; this turns the search for connections between photochemical practices and historical accounts of the use of natural pigments for these practices into something of a grail mission.

Regarding said search for sources on the discussed topics, one is forced to concede that the amount of artistic work and accounts referring to both botanical colour extraction and photography simultaneously are sparse, however, they are not

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[235] FINLAY, Victoria. *Color: A Natural History of the Palette*. (EBook) New York, USA: Random House Publishing, 2007. ISBN 9780307430830

non-existent. In-depth research into the history of colour making, pigment extraction and photochemical reactions in early dyes uncovers the true path of this niche subject, namely one that has paved the way for modern processes of dyeing and colour making as well as the medium of photography.

In this context, the pigments most closely connected to photographic practices, including ancient naturally derived colours such as Tyrian Purple[236] and more modern, artificially derived ones like Prussian Blue[237] are ones that either go through a visible change in colour upon exposure to sunlight, or those that possess a high level of photosensitivity and quickly fade in bright light.The latter of these attributes would have been especially annoying in colour application practices like painting, wherein the final work would be exposed to the elements and subsequently fade, losing its crisp, original colouration. But, in photographic practices, this is exactly the characteristic that made a pictorial imprint possible; without the ability of the pigment to react photochemically and fade, no image would be visible. This then, of course, pointed to a need for fixation techniques to ensure the longevity of the image; however, as seen with the first photographic publication, *British Algae,* by Anna Atkins[238], a new medium to publish photographs without exposure to direct sunlight came into existence, ensuring their safe storage within the pages of their innovative book format.

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[236] EDER, Josef Maria. *History of Photography*. New York, USA: Dover Publications, 1978. ISBN 0-486-23586-6, further discussed throughout the whole of the first chapter

[237] As discussed in Mike Ware's various works on Cyanotypes

[238] ATKINS, Anna. *Photographs of British Algae: Cyanotype Impressions (Sir John Herschel's Copy)*. Göttingen, Germany: Gerhard Steidl Druckerei und Verlag, 2022. ISBN 9783958295100

Accounts of photographic artists that have made use of the medium of natural pigments are found throughout history, to include Anna Atkins' cyanotypes and Mary Somerville's anthotype explorations; on the other hand, contemporary artists creating photographic prints with pigments they collected and extracted themselves are certainly not non-existent either, as demonstrated by Jan Jedlicka's abstract landscape representations or Susanne Kriemann's ‘‘radioactive prints''. Diving into the history of early photosensitive reactions and their adherent experiments has also shown that the path for Talbot and Daguerre has been paved by Elizabeth Fulhame and her experiments in creating cloths of silver and gold, and that Anna Atkins' *British Algae* is essentially the precursor of the modern photographic publication.

Fulhame's work shifts the topic into specifically feminist realms, clarifying the importance of female scientists throughout history and underlining the seeming loss of this knowledge as well as its overshadowing by well-known male scientists such as Talbot and Daguerre. These, not infrequently, received praise for work that was, in fact, conducted by a woman before they ever started their own experiments. Thus, it becomes apparent that, though experiments connected to pigment extraction and photosensitive reactions may be attributed to male scientists and alchemists, these endeavours were decidedly not overlooked by the female members of society, who not only made use of all the above mentioned practices, but oftentimes made the work of their more celebrated male counterparts possible.

There is, additionally, a long and prevalently female history in the study and use of botany and herbalism, which is clearly reflected in the various paths leading to alternative photographic methods like cyanotypes, anthotypes and, as discussed

above, even the silver process. With regard to the depiction and presentation of photography, Anna Atkins must be recognised as a truly important female trailblazer finding her way into the most prestigious and important scientific circles of her time, making valuable contacts with scientists like Herschel, the father of the cyanotype, and self-publishing her research and collected works without any help from the outside world. This determination is to be valued and admired because of the struggles and difficulties posed by being a woman in the male-dominated fields of the time.

In the context of re-enchantment, there are certain, clear parallels between the rise of science and the consequent fall of religious or spiritual beliefs and the development of pigment extraction as well as the artificial synthesis of the same. Before the 18th century, pigments for painting and printing were largely extracted from organic materials to include plant, mineral, and animal sources. However, with the rise of alchemy as well as the Catholic church's approval and support of it at the time,[239] experiments, research, and the newly acquired but steadily expanding knowledge of elements and chemical reactions ensured that the trend for pigment extraction skewed towards the artificial and cheap where it has remained ever since.

This does, moreover, point out the duality with which women and men practising similar crafts were treated; only a few years after thousands of women died following the European witch hunts, men were allowed to actively and openly seek for magically inclined things such as the elixir of life, and the positions of Alchemists then

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[239] MARSHALL, Peter. *The Mercurial Emperor: The Magic Circle of Rudolph II in Renaissance Prague*. London, UK: Pimlico, 2007. ISBN 9781844135370

developed into those of chemists and scientists who went on to create (or at least to have attributed to them) the basis for modern scientific knowledge, while women were only allowed to enter this world gradually and cautiously, under the watchful eye of the patriarchal establishment.

The rise of disenchantment has, additionally, moved humanity away from the nature and magic that had been an integral part of human life for thousands of years. Practices, traditions, and rituals that are today seen as esoteric and mystical have long been part of society but are frowned upon by those that follow the agenda of modern scientific knowledge, which aims to rationally explain anything regarded as supernatural. This connection to nature was replaced with artificiality: food made in factories, a focus on science, and the inexpensive mass production of anything imaginable. This makes it seem as though humans are not meant to live in unison with nature anymore and must not by any means try to reconnect to spiritual roots wherein spirituality does not have any connection to religion, but rather to a deep sense of what it means to be human. Furthermore, any step away from science and factories (specifically by people that have not grown up in lower-middle class conditions where practices like growing one's own food or creating one's own resources) may be construed as something of an act of rebellion. We are talking, of course, of the West and its connections to magic and witchcraft. Other countries still have a very strong representation of these subjects, however, what tends to exist in conjunction with that is little-to-no access to medical facilities, modern education, or means of mechanical transport. This opens the question of whether we need to live

the way prescribed by modern Western thought, and whether establishing a reconnection to nature is possible in this part of the world.

On this account, however, it may be argued that there are still several existent European, and therefore westernised, countries that may not have ever gone through a complete disenchantment, such as Ireland as discussed by J. A. Josephson-Storm[240] using the example of the changeling phenomenon that appeared in the country in the late 1800s. This was only the beginning of such accounts and the last century, specifically the past sixty years, have certainly seen a rise in practices connected to religion, magic, and spirituality. One such example is the neopagan movement, Wicca, largely coined by Aleister Crowley[241], as well as The Church of Satan[242], to name but a couple.

To bring disenchantment into the context of the return of ancient crafts like pigment extraction, one has to think about what the word magic used to mean, and what it means now. Today, magic is exemplified in the flashes and spells of *Harry Potter*. Magic, however, used to be an everyday part of life, encompassing many of its aspects through healing, midwifery, and herbalism, all of which have basically been replaced by modern, cheap, and commercialised versions of the original, nature-connected arts or crafts. Therefore, disenchantment has not only taken place in terms of a step away from spirituality and religion, but also permeated into

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[240] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences*. Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 125

[241] CROWLEY, Aleister. *Magick: Liber Aba Book 4 (Magick Book 4)*. York Beach, MI, USA: Weiser Books, 1998. ISBN 9780877289197

[242] Church of Satan. (online) Available from https://www.churchofsatan.com/ (Accessed 12.04.22)

practices that used to be done by hand (especially those connected to crafts and arts) but are now produced entirely in factories, robbing humans of their personal connection to the final product as well as the opportunity of creating a sense of community by trading, and directly profiting from, the product themselves.[243]

A return to ancient and historical processes is, however, taking place, specifically in younger generations that, due to social, political, and global factors (e.g., pandemics and wars) is starting to see the world differently. Indeed, there seems to be a certain process of awakening; nor is this the first time a mass-awakening on this scale has happened, as demonstrated during the 1960s and 70s with the example of the Hippie movement.[244] Today, a similar spirit can be observed in commercial phenomena like small businesses and ‘‘craft-consumers’’, but is also present in a social demographic shift of young people moving out of the cities into rural areas to follow a more traditional way of life or the rise of spiritual, magical and ritualistic practices and interests beginning to unfold in younger generations.

This return can also be observed in alternative photographic practices involving old processes like cyanotypes and anthotypes as well as in the rise of old techniques of pigment extraction, colour making, and printing processes. Thus this thesis draws to its conclusion by drawing clear lines between these subjects, each of which are, in

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[243] BRATICH, Jack Z., and BRUSH, Heidi M. “Fabricating Activism: Craft-Work, Popular Culture, Gender.” Utopian Studies, vol. 22, no. 2, 2011, pp. 233–60, https://doi.org/10.5325/utopianstudies.22.2.0233 (Accessed 10 Apr. 2022), p. 234

[244] JOSEPHSON-STORM, Jason A. *The Myth of Disenchantment: Magic, Modernity and the Birth of the Human Sciences*. Chicago, USA; London, UK: The University of Chicago Press, 2017. ISBN 978-0-226-40336-6, p. 36

their own way, deep and vast enough to fill thousands of pages respectively without the interference of other themes.

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Figure 7: Jan Jedlička, Maremma, 364 colouri, 2019 - 2020. Available from https://www.ghmp.cz/wp-content/uploads/fly-images/15979/jedlicka_01-99999x700.jpg (Accessed 13.04.22)

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