2008

Re-imaging nature

Mary Rosengren

University of Wollongong

Recommended Citation
NOTE
This online version of the thesis may have different page formatting and pagination from the paper copy held in the University of Wollongong Library.

UNIVERSITY OF WOLLONGONG

COPYRIGHT WARNING
You may print or download ONE copy of this document for the purpose of your own research or study. The University does not authorise you to copy, communicate or otherwise make available electronically to any other person any copyright material contained on this site. You are reminded of the following:

Copyright owners are entitled to take legal action against persons who infringe their copyright. A reproduction of material that is protected by copyright may be a copyright infringement. A court may impose penalties and award damages in relation to offences and infringements relating to copyright material. Higher penalties may apply, and higher damages may be awarded, for offences and infringements involving the conversion of material into digital or electronic form.
Re-Imaging Nature

A thesis submitted in partial fulfilment of the requirements for the award of the degree

**Doctor of Creative Arts**

from

**University of Wollongong**

by

**Mary Rosengren**

*Dip Arts, Grad-Dip Visual Art, Grad-Dip Ed.*

**Creative Arts 2008**
I, Mary Rosengren, declare that this thesis, submitted in fulfilment of the requirement for the award of Doctor of Creative Arts, in the Department of Creative Arts, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Mary Rosengren
October 2008
Volume One
Table of Contents

Volume One

Abstract 1

Introduction 2

Chapter 1—Imaging Nature: a visual inventory of the world 11
  1.1 Imaging nature 11
  1.2 An accurate visual inventory of nature 12
  1.3 Authentic origins and doubtful copy: De Materia Medica and Codex Vindobonensis 15
  1.4 Book-making and the “currency” of images 19
  1.5 Style and “unnatural icons”: illuminated manuscript copy in early printed herbals 21
  1.6 Printed books and watercolours 24

Chapter 2—A Metamorphosis New Worlds trust and truth 31
  2.1 Merian and mid-seventeenth century Europe 33
  2.2 Use, Beauty and a collectable aesthetic 34
  2.3 Reconciling the exotic New World 35
  2.4 Catalogues (of nature) 36
  2.5 Interior world of Dutch flower painters 37
  2.6 Nature bound and dressed 38
  2.7 Visualizing new worlds 39
  2.8 Revealing nature 40
  2.9 A dynamic symbiotic microcosm 43
  2.10 The legacy of the copy (published engravings) 44
  2.11 Spontaneous generation: the paradox of microscopy, comprehension and credibility of new New Vistas 48
  2.12 Disrupting the decontextualized space: a new graphic language 49
  2.13 Vision & limits of the retina 51
  2.14 The Microscopic sensibility 54
Chapter 3 — Herbae nudae and icontype: the graphic conventions of herbals and the botanical treatise  
3.1 Characteristic difference: description and analysis  
3.2 “An uneasy relationship”: the status of the visual in printed herbals, text, image and copying practices  
3.2.1 Colour in woodcuts  
3.3 Specific and general plant portraits: the real time observations in Brunfels’ Herbarum Vivae Eicones (1530-36) and Fuchs’ De Historia Stirpium (1542)  
3.3.1 An early type specimen  
3.3.2 Taking peculiar care: Leonard Fuchs (1501-1566) and De Historia Stirpium (1542)  
3.4 Inclusion and connection “herbae nudae” and “icontypes”: the partnerships of Georg Dionysius Ehret and Carl Linnaeus, Ferdinand Bauer and Robert Brown  
3.5 Plant chemistry and taxonomy  

Chapter 4 — Foreign Musci: chemistry and biology  
4.1 Eighteenth century microscopes  
4.2 Coherence: images, texts and specimens in the herbarium  
4.3 Greville’s specimen sheets as tools  
4.4 Coherence and con-text: purpose image and text  
   Behind Plate LVII: Visual Textual Descriptions  
   Fitch’s Sphagnum: a cross-section and cells (1830s-1840s)  

Chapter 5 — Over the Rainbow  
5.1 Insight: from botany to biological science (Robert Brown nuclei)  
   Hooke’s juices: the space of the cell and cell structures (Wilson and Tagawa)  
5.2 Subcellular phenomena and visualization: new graphic language  
5.3 Space: cell images as maps (Figures 5.05, 5.06)  
   The absence of volume, decontextualized-space and colour  
5.4 Filling Hooke’s void  
5.5 Colouring in  
5.6 Veracity and value of images
Chapter 6 — Observation and Experience 122

6.0 Seeing and Knowing: going back Fruitingbodies & Groundcover 1999-2000: behind the research and creative work Re-Imaging Nature (2002-08) 123

Vegetation in extreme environments 128
Gathering material: in the field and laboratory 129

6.2 Hidden Visions: a space of observation 131
6.3 Ground Truth: immersed in sight and sound 136
6.4 Research summary 139
Appendix 1 144

Works Cited 145
Bibliography 153
Acknowledgements 161

Volume Two

List of Illustrations
Illustrations—Figures 1.00-6.08
Appendix — Supplementary material 2-3
Appendix 2 — Supplementary material CD-ROM 1
Appendix 3 — Supplementary material CD-ROM 2
Abstract

This study examines specific visual systems of representing vegetation in western science. Through digital and analogue printmaking, artist's books, projection and sound installation my creative work uses the imagery of plants to explore the lacunae between contemporary visual art and western science.

Looking at early plant representations from the copy of the first century BC Dioscorides' *De Materia Medica* in the *Codex Vindobonensis* 512, to Hans Weiditz and Leonhart Fuchs' woodcuts at the beginning of the sixteenth century, and through to Carl Linnaeus in the eighteenth century, the study shows the interrelationship of knowledge to image, and the importance of visualizations to an emerging scientific framework in categorising all plant species. A significant figure, in the development of empirical visual knowledge, and situated between art and science, is the artist and entomologist Maria Sibylla Merian (1647-1717). Drawings at this point and in following centuries constituted knowledge and European conventions of representing botanical subjects were recognised as a universal graphic language as exemplified in the works of botanist botanical artist Walter Hood Fitch (1817-1892).

Improvements in microscope lenses, the development of photography and chemistry in the nineteenth century combined to produce new knowledge and techniques for observing and representing nature that have since challenged these universal graphic conventions in the task of representing the plant subjects of biological science.

In recent geo-science and biological research another visual system of representation has become dominant through remotely sensed data, and the development of the digital has allowed new comprehensions of scale, colour and form in installation works, such as Mona Hatoum’s “Corps étranger” (1994) and Drew Berry’s animation of molecular processes “Apoptosis” (2007).

Research using confocal microscopy and Landsat Multispectral Scanner imagery reflect how perspective, spatial resolutions and spectral characteristics, (acquired, transmitted and archived by machines), are radical departures in visualising processes and functions of the natural world. This research does break new ground in investigating overlays between science and visual art in observation, experience and visualisation of nature by electronic technologies.
INTRODUCTION

In order to understand the spaces between art and science I have considered art works and scientific space(s) of display and the way immersive sensory experiences converge with structured formal spaces of observation.

"...one aspect of our reading (of works of art) is based on notions of the power of representations to mirror or simulate reality itself. This is associated with the privilege of sight over the other senses in western philosophical discourses on knowledge. To see, fully and accurately, is to know; consider the enormous significance granted to seeing bodies, cells and atoms in our scientific understanding of the world. To represent the objects in the world correctly is to know and understand them. Representation is inextricably linked to the power of knowledge."


The background to this topic “Re-imaging nature” is the work in my digital-prints Fruitingbodies and the installation Groundcover 2000 (Figure 1a-b) that refer to a scientific means of viewing the natural world as in the quote above by Marsha Meskimmon. Such images raised questions about visualization, technology, the intersections of areas of specialist knowledge, including the legacy of a dualistic philosophy and the relationship between specialist practices in western art and science.

This research examines the lacuna between art and western science and the implications of digital imaging for this relationship in the following ways:
1. The historic role of ‘the visual’ in the development of botanical science.

2. Connections between technologies of observation and visualization: a) graphic conventions of representation, b) the practice and purpose of artists and scientists.

3. The use of imaging in contemporary biological science practices of botanical subjects; the digital aesthetic of imaging technology, in representations of nature and for visual art practices of installation and print.

4. The role of technology in the development of graphic conventions in contemporary botanical / biological images.

In his essay “The nature of Nature” the eminent philosopher, scientist and writer George Seddon stated that, “The ways in which we perceive, imagine, conceptualise, image, verbalize, relate to, behave towards the natural world are the product of cultural conditioning and individual variation”(13). Seddon summarized how we “conceptualized ‘Nature’ in three ways that are not compatible in logic”. The two extreme positions are “that we see ourselves as part of Nature”, and “that natural systems are self-regulating and self-maintaining, with our species seen as of very minor significance in the scheme of things”. Between these positions is the concept that “our species (is regarded as) a part of Nature, yet at the same time responsible for managing it.”(14)

With this in mind, I have considered the projected video installation Corps étranger in Figure 2(a-b), by the Palestinian born UK based artist Mona Hatoum (b.1952-) that resulted from the invasive endoscope imagery of her own body. To see Hatoum’s presentation of this invisible domain, I entered an intimate semi enclosed structure where the visual experience was heightened by sound and
a blurring of the boundaries of personal public space and of medicine and science.

Installations by the Danish artist Olafur Eliasson (b.1967-) The Weather Project 2003 and Waterfall 2005, explore the boundaries between seeing and experiencing of nature (Figure 3a-b). In the middle of a northern hemisphere winter, the faux sun of the Turbine Hall of the Tate Modern, The Weather Project, offered a real, sensory experience to its audience: the photo in Figure 4 shows Londoners basking in its reassuring atmospheric orange warmth. This installation might have received another (opposite) response altogether in an Australian art gallery. Eliasson’s works explore the experience of the spectacle of natural phenomena and the relationship of the viewer to it, often by reversing the context of viewer. In Waterfall 2005 Figure 3(b) the viewer is re-positioned outside. In these works the viewer-participant is simultaneously part of the work and observer of nature.

In scientific spaces of observation and display such as the Rotunda Museum Scarborough Yorkshire 1828 and the Sub-Antarctic Plant House Royal Botanic Garden Hobart, the visitor has the sensory experience of being in and part of nature, as well as being an observer of nature (refer to Figure 4a-b). These spaces are part of another tradition that offers well understood experiences of nature that exploit the boundary between observation and experience for education and entertainment. These spaces of art and science utilize common strategies in their designs and presentations where the viewer’s sensory experience is extended, but it is their respective purpose, value and meaning that defines the way they are regarded.
The Rotunda Museum was one of the earliest purpose built museums in Britain, its display of fossils was designed to convey William Smith’s (1769-1839) theory that rocks could be ordered according to the layer of fossils they contain. Display cabinets lined the walls of the dome above head height and the arrangement of this display and of the samples illustrated their position in geological time. When I visited the Rotunda the faded frieze below the cabinet display showing the strata of the coastal rocks painted by his nephew (1820s) could still be seen. The Rotunda was the location for meetings of the Scarborough Philosophical Society.

The thesis, after investigating historical imaging of nature, moves on and explores the paradox of digital imaging technology. This recent innovation in imaging has veridical authority for western science and gives contrary possibilities for invention and deception. I propose that although these qualities are historically characteristics of western art, they are less evident in contemporary visual arts practice, than the veracity of sensory experience. The implications of digital mutability and falsehood are well documented (in William J. Mitchell’s Reconfigured Eye (1994), and their challenge to the hegemony of the visual art traditions of representation - drawing, painting, photography, are reflected in contemporary visual arts forums3 (conferences, journal publications and exhibitions), and essays such as Johanna Drucker’s “Graphesis or Mathesis”.

I will address issues of how these visual art traditions of representation inform the visualizations of science, and the way visualization by new technologies in science contribute to re-imaging nature and the status of images in contemporary art practice. The use and role of images by science is recognized and examined by historians of western science such as Michael Lynch to be
extensive and central to their work. In the conclusion of her study of the images of natural history from the late sixteenth to early nineteenth century, the curator and writer Victoria Dickenson (1998) stated that “not only do scientists think in pictures, but in some cases their thinking may take the form of a picture before it can be understood and communicated at all” (234). This has been reiterated by the critic James Elkins “scientists make more images than artists and their work is centrally concerned with imaging” (36-37). He questions the assumption that (image) manipulation only occurs after raw data is obtained, and the role of contemporary practice in the visualization of knowledge, where pictorial conventions of visual art are adopted (by scientists) without reference to their art historic origins. The sociologist Michael Lynch has analyzed the role of images and inscriptions in the laboratory as fundamental to the process of western science research practices.

In response to the re-orientation towards a contemporary digitized visual culture the art historian and theorist Barbara Maria Stafford argued for the following strategy:

“We need therefore to get beyond the artificial dichotomy presently entrenched in our society between higher cognitive function and supposedly merely physical manufacture of “pretty pictures.” In the integrated (not just interdisciplinary) research of the future, the traditional fields studying the developments and techniques of representation will have to merge with the ongoing inquiry into visualization. In light of the present electronic upheaval, the historical understanding of images must form part of a continuum looking at the production, function, and meaning of every kind of design.”
I will examine how the digital aesthetic affects practice, gives or removes credibility, and re-values the relationship between areas of knowledge. On occasions where boundaries are redrawn and blurred there are implications for the relationship we have with nature. Gombrich (278) in *The Image and the Eye* refers to it as “the question of what in our world is part of nature (physis) and convention (thesis, nomos, ethos)”⁴. With the simplicity of binarism the in/here out/there of the dualistic model of Cartesian science accommodated a changed relationship between the observed and observer. I explore how this changes ideas about nature and culture.

The exhibition *Re-imaging Nature: Hidden Visions and Ground Truth* 2008 at the FCA Gallery, University of Wollongong NSW explored the implications within and between specialist disciplines of artists reconnecting with scientific practitioners, their technology and their imagery. Between the two spaces of this work, through print, sound and installation, the position of the viewer is fundamental to the work and the distinction between “inside” and “outside” dissolves. The first Chapter Imaging Nature begins addressing these issues by considering the changed status of botanical images, developing from oral visual manuscript culture and the early printed herbal books.

In Chapter 2 A Metamorphosis, New Worlds - trust and truth, the transition from Pliny’s mistrust of images to the taxonomic achievements of Cartesian science, is shown in the convergence of the new New World and the effects of (new) ocular and print technologies of Maria Sibylla Merian’s (1647-177) florilegium
with insects *Metamorphosis Insectorum Surinamium*, Amsterdam, 1705. This publication signals the beginnings of the task of creating an empirical visual inventory of nature (as opposed to the sublime) and ideas of mastery of nature. The descriptive quality and accuracy of Maria Sibylla Merian's watercolors and prints from Surinam are regarded as significant for revolutionizing the sciences of botany and zoology. Merian's achievement is considered to have laid the foundation for the subsequent classification of plant and animal species by Charles Linnaeus in the eighteenth century. *Metamorphosis* is considered a benchmark (Dickenson 148) for subsequent works of natural history concerned with the New World and raises issues about the technology of observation, representation, and visual knowledge in specialized interdisciplinary practice where visualization is central to scientific work. In addition to Merian's significant contribution to the development of a universal graphic language for botanical science in the seventeenth and nineteenth centuries was her ecological regard for nature and portrayal of temporal processes, and its relevance to twenty-first century concerns and positions.

Echoing aspects of the Merian's epoch, Chapter 3, *Herbae Nudae Iconotype* outlines issues brought to illustrators of botany and taxonomy by printing, and explores the development of universal graphic conventions to represent botany's taxonomic concepts. The discovery of the microscopic scales of cells and their magnified images from the nineteenth to twenty-first century biology are considered in Chapter 4 and 5. The discussion considers the role of optical and new imaging technology and the emergence of a new graphic language in the hands of artists and scientists in the late twentieth and beginning of the twenty-first century such as Drew Berry. The meaning, value and purpose of these images is a radical departure from graphic conventions of botany, and
has affected the way in which visual material is used and regarded once it has been taken from its original context in the laboratory or research paper and displayed in news articles and other non-specialist publications. The visualisation of data such as the confocal microscope cell images or the Landsat (satellite) image with their veridical digitized inventory, re-image and reinterpret nature with empirical computational data. Nature - the body and the environment, are redefined by microscopic and macroscopic technologies of observation. Visualisation is essential in understanding such phenomena and what Dickenson refers to as “systems and the nature of the world” (236). The “digitally diaphanous” virtual culture of interchangeable data and code that Barbara Maria Stafford refers to, particularly the images of remotely sensed data of satellite and scanning electron microscopy, present radical new parameters for visual art practice.

My work is compelled by the understanding that the physical natural environment is an immersive sensory experience. Conversely, the experience of nature in science (in the laboratory and the field) is continuously rewritten and drawn by a visualising from microscopes to satellite technology that isolates, clarifies and objectifies. In this scientific milieu, nature becomes the specimen. Re-imaging Nature explores the lacuna of this schism. Finally, Chapter 6 describes the creative work Re-imaging Nature 2002-08 and the way in which observation and experience converge in the visual and auditory space of the installation Hidden Visions and Ground Truth 2008.

As a reference point, I am including the diagram from the textbook by Murray Nabors (29), Introduction to Botany (2004) shown in Figure 5, that illustrates optical scale as opposed visual scale.
2 Richard Feynman’s 1963 lecture The Uncertainty of Science. “What is science? The word is usually used to mean one of three things, or a mixture of them, ...science means, sometimes, a special method of finding things out. Sometimes it means the body of knowledge arising from the things found out. It may also mean the new things you can do when you have found something out, or the actual doing of new things. This last field is usually called technology.”

3 Three examples in the UK include Welcome Trust (medical research charity) that promotes science art collaborative practices through “sciart” projects; Intellect Books and the CAiiA -STAR conferences.


Chapter 1
Imaging Nature: a visual inventory of the world.

Introduction

In this chapter, Imaging nature, I consider the historic background to the development of the idea of an “accurate visual inventory” of nature, and the complex relationship between the status of images, technology and practices of representation.

The chapter examines the route of early botanical knowledge from Dioscorides’ De Materia Medica in the first century BC; the sixth century illustrated manuscript of this text Codex Vindobonensis, and incunabula¹, as well as printed herbals of the sixteenth century. These documents illustrate factors which contributed to the varying status of images and visual knowledge, and this discussion shows how this changed between the naturalistic representations of plants in Classical documents, their emblematic interpretation in herbals and the re-emergence of naturalism in the Renaissance classical revival.

1.1 Imaging Nature

“...most scientific illustrations are drawn from earlier reference images, rather than from life.”

Brian J. Ford (1992), qtd. in Dickenson (34).

Botanical knowledge, the practice of plant description and identification, has been central to the development of pharmaceutical, medical and scientific knowledge in the west. In the first part of this chapter I explore plant descriptions, and the changing status, value and purpose of text and image in the history of botany.
Attempts to develop “a visual inventory of the world”, of botanical pharmaceutical, medical and scientific knowledge, reflect the complex relationship between accurate description and identification of plants, the methods of representation and technologies of visualization.

The visual and written description of nature over a large span of western history shows a convergence of art and science through the technologies of observation and the methods of representation and reproduction.

1.2 An accurate visual inventory of nature.

The development of a visual inventory of the world is synonymous with ideas of nature and Enlightenment science that can be traced through translations and interpretations of documents and artifacts held in European museums and libraries. Classical knowledge contained in them shows the route of early medical and scientific knowledge over the period of 1600 years from Hellenistic Greece, Byzantine Constantinople to the European classical revival of the Renaissance.

In his book A Brief History of Science (2001) the scientist and writer Thomas Crump (25) describes the significance of Greek antiquity, and the persistence and implications of Aristotle’s (c.384-322 BC) legacy in the treatise Physics, for the subsequent development of science in Western culture.

“...all his [Aristotle’s] scientific thinking was dominated by his belief in fundamental principles... in his Physics. Of these, change and nature as the source of change, were the most important, ... and [Aristotle] insisted that all the changes observable in the universe must have had a first cause. This must be God. Aristotle’s God embodies the principle of reason, as opposed to observation and experiment, which Aristotle saw as
irrelevant to such general topics as matter, space, time and motion, although not to natural history.” (Crump 27)

Botany can be identified as a distinct body of knowledge in two treatises by Aristotle’s pupil Theophrastus (378-287 BC), *Historia de Plantis* (The Inquiry into Plants) and *De Causis Plantarum* (The Causes of plants or The Growth of Plants. In his authoritative history of botanical images and knowledge *The Art of the Botanist* 1980, the historian Martyn Rix (8) explains that these fourth century works are predominantly concerned with plants of the Mediterranean region and their use for food and medicine.

Theophrastus’ observations of the 500-550 cultivated species and varieties in the Lyceum garden in Athens identified various means of plant reproduction, and contain “a discussion of plant anatomy” and “a proposed system of classification” (Rix 8).

There are no images of plants surviving with Theophrastus’ works but it is assumed that the images of plants would have been adequate for identification (Rix 8). This speculation is based on the high value of naturalism and accuracy in Greek painting and sculpture, and clarity of plants represented in frescoes, vase painting and mosaics, and on coins.

The probable accuracy of these plant images is supported by the art historian Ernst Gombrich in *The Story of Art* (1950) writing of the earlier observations of nature in Egyptian art, such as Figure 1.01 showing details of birds in a bush from a wall in the tomb of Chnemhotep near Beni Hassan about 1900 BC.

Figure 1.01 shows a small section of the entire wall in the tomb of Chnemhotep. Although flattened, the branches and leaves, resembling sage coloured acacia with round orange fruits spread decoratively, offer a consistently dense backdrop for five perching birds. Of the nine birds shown in this Figure there are three to four different head, beak and body shapes. Among these are detailed and varied patterns of the
feather markings, one with its wings outstretched; on the left side is a bird with a distinctive orange crest and to the right are the sleek profiles of water birds.

Gombrich writes: “[...] this geometrical sense of order did not prevent him (or her) from observing the details of nature with amazing accuracy. Every bird or fish is drawn with such truthfulness that zoologists can still recognize the species” (38). In his study of perception and pictorial representation Art and Illusion (1960) Gombrich also cites the refinement of the “schemata of animals and plants” in the art of Egypt and Mesopotamia, or Crete. He credits the “directed efforts” of Greek artists with producing the legacy of mimesis (imitation of nature) that “linked art with the solution of problems” (120-123).

In his essay Visual Discovery through Art (13) Gombrich (1982) refers to the way mimesis, or “plausible rendering of nature” was considered “the basis of art for the ancient world”, (and for the “masters of the Renaissance”). The birds detailed in Figure 1.01 may never have congregated in such close proximity in one tree but the techniques of trompe l’oeil (trick the eye) and mimesis combine with foreshortening, overlap, light, shading (used in painting to mirror reality and place the viewer “physically and emotionally” there). All these visual techniques were used skillfully by the artist to contribute to the visual inventory of nature.

There are references specifically to images illustrating plants in Pliny the Elder’s first century AD Historia Naturalis (Natural History). Pliny became the basis for understanding the extent of scientific knowledge at the beginning of the Middle Ages (Banks 123). Of the 37 volumes covering natural history (twelfth century pmanuscript copies extant in the British Library) there are 15 books about botany, and in them he describes the cultivation of plants and their medicinal uses (Banks 123).
The convoluted journey of knowledge, the relationship of images and text, their translation, copy and reproduction is embodied in the story of the first century images that appear in the sixth century *Codex Vindobonensis* in Constantinople, and which can be seen to reach as far as the eighteenth century and to Carl Linné (1707-1778).

1.3 Authentic origins and doubtful copy: *De Materia Medica* & *Codex Vindobonensis*.

In her comprehensive study of images *Drawn From Life: Science and Art in the Portrayal of the New World* in 1998 the Canadian curator Victoria Dickenson (81) describes the 1st century BC physician Crateva, as the most famous botanist after Theophrastus whose images of plants were being used as the basis for prints in *Gerard’s Herball* in the 1530’s. The persistence of these images into the seventeenth century is endorsed by Rix (9), who also states that Thomas Johnson published Crateva’s images as late as 1633. These images and the document they became attached to, *De Materia Medica* (On Medical Matters) by the Greek physician Dioscorides (c. 40- c.90) were described by Johnson as “the foundation and grounde-worke of all that hath been since delivered in this nature” (Rix 10).

The original work of Dioscorides, which contained a list of 500 plants with their names and the healing properties was written in Greek and later translated to Latin as *De Materia Medica*. The original Greek text does not survive and it is considered likely that originally it was without illustrations.

Dioscorides’ *De Materia Medica*, preserved by Arab cultures was translated into Latin in the tenth century. Although Dioscorides (and Pliny) were in print’ (Dickenson 81) in Germany by 1478 (the Greek version in Vienna 1489), the paintings attached to *Codex Vindobonensis* remained in Constantinople until 1569 (Rix 12).
Cratevas’ illustrations were reproduced in the Byzantine copy of Dioscorides, in the work known as Juliana Anicia Codex of Dioscorides referred to as Codex Vindobonensis or Codex Aniciæ or Vienna Dioscorides. This manuscript book was made for Anicia Juliana⁸ (ca. 512 AD) in Constantinople where it remained until the second half of the sixteenth century. Rix refers to it being seen there in 1562 although by 1569, it was in the Imperial Library in Vienna (12).

The 500 sheets of parchment represented in Figure 1.02 are 30 cm square and comprise 400 full page painted illustrations of plants and others of birds. The three pages shown here include the plants (a.) Chaste tree (Vitex agnus-castus), (b) Lords-and-ladies (Arum marculatum L.;f 98r), (c) Opium poppy (Papaver somniferum). The painting and drawing shows the whole plant from root to crown and in flower. Each plant is drawn in a central and isolated position on the page. The neutral background contains several lines of text, and in Fig. 1.01(b) Chaste tree this is positioned above the specimen. In Figure 1.02(b) Lords-and-ladies the faded text also runs through the central background section of the drawn image. It is considered by the Austrian scientist and academic Professor H. Walter Lack (24) states in 2001 that the images were based on illustrations from Rhizotomicon of Cratevas (Sarton 382), and notes in Arabic, Persian and Turkish indicate the Codex was in use after the second fall of Constantinople 1453.
**Images not from nature**

In 1785 this manuscript *Codex Vindobonensis* was studied in Vienna by John Sibthorp, Professor of Botany at Oxford and his artist associate Ferdinand Bauer, who subsequently spent five years on an expedition to collect plants of the eastern Mediterranean. A partial copy was in the possession of Carl Linné (Fig. 1.04) and as Dickenson describes, “for early-eighteenth-century naturalists the botanical knowledge that began with Dioscorides ran in an unbroken chain through the centuries”.

Figure 1.04 shows proofs of eighteenth century engravings copied from *Codex Vindobonensis* and sent to Carl Linné with notes from Nicholas von Jacquin which are now in the library of the Linnean Society London. He lent another copy to John Sipthorp for his work on *Flora Graeca*.

Although dated to the sixth century AD the naturalistic appearance of the plants in *Codex Vindobonensis* (Fig. 1.02. Paintings from facsimile of *Codex Vindobonensis*) are in the loose and painterly Greco Roman style. Their Hellenistic origin is endorsed by Wilfred Blunt as having the “naturalism alien to Byzantine art of the period” (qtd. in Rix. 12) and they contrast with the dedicatory miniature to Anicia Juliana (Figure. 1.03) which has the visual rigidity of the stylized static Byzantine mosaic.

Other dedicatory miniatures in the *Codex Vindobonensis* are evidence of its Greco Roman origins (Rix 12). One of these represents Dioscorides at work, and the second is reminiscent of a wall painting at Pompeii and in it Cratevas draws a mandrake being held by Intelligence (12).

---

1 Rix suggests John Sipthorp Professor of Botany at Oxford (and Ferdinand Bauer’s *Flora Graeca* (10 volumes 1808-40) to be possibly the greatest illustrated flora ever written. In 1785 Bauer (1760-1826) accompanied Sipthorp, as his draughtsman on his botanical survey of the Aegean, and
The value of images was noted by Pliny the Elder and refers specifically to paintings by Cratevas and other Hellenistic botanists. 

“...the subject has been treated by Greek writers, whom we have mentioned in their proper places; of these Cratevas, Dionysius and Metrodorus adopted a most attractive method, though one which makes clear little else except the difficulty of employing it. For they painted likenesses of the plants and then wrote under them their properties. But not only are the pictures misleading when the colours are so many particularly as the aim is to copy nature, but besides this much imperfection arises from manifold hazards in the accuracy of copyists....For this reason the writers have given verbal accounts only”
(qtd. in Rix. 9)

Pliny’s mistrust and doubt about the value of the visual recognizes that without the accompanying written description the images are problematic and unreliable for purposes of identification. In addition to inaccurate and inconsistent colour, the obstacles to their credibility are the issues of copy. Although regarded by Rix (12) as “the most beautiful and oldest”¹⁰ the Codex Vindobonensis was not the only manuscript copy of Dioscorides. Figure 1.06 shows another of the numerous versions of Dioscorides', De Materia Medica from Baghdad from about the seventh century.

In the quality of parts of the Codex illustrations Rix observes the way the artist shows “the join of the stem and leaf of the sow thistle”. Different copyists, working at different times as well as variations in material and purpose, would have compounded this awkwardness. The status of the image remains static within the oral visual manuscript copy tradition. Production of “the exactly repeatable...(visual or pictorial statements)”

---

¹⁰ later in 1800 Bauer embarked with Matthew Flinders on the five year voyage of exploration to Australia. Fig. 7. is an example of Bauer’s accuracy and draughtsmanship.
is the achievement of printers and engravers of the mid fifteenth to nineteenth century (William Ivins Jr. qtd. in Dickenson 11).

Although Rix (9) suggests that the purpose of the illustration that Pliny refers to was identification similar to the later illustrated floras, this comparison needs qualification. The period for establishing representations with visual accuracy for the purpose of identification was moribund for centuries. The status and authority of the image in Enlightenment science was stimulated by cultural and technical changes in the Middle Ages, and reformed by the ocular revolution of the Renaissance, (of which the floras are at the beginning).

1.4 Book-making and the "currency" of images

The transition from Pliny’s ambivalence about images to their central role in sixteenth century botany owes much to changes in the production of books; what can be referred to as the technology of knowledge.

Comparisons between three books and the quality of visual (botanical) information across 1500 years, from the illumined manuscript Codex Vindobonensis (Figure 1.02); to the fanciful emblematic images of (various) manuscript herbals of the Middle Ages, and the Herbarum Vivae Eicones 1530, shows the differences between function, purpose and technology of production (Figure 1.10 Hans Weiditz) and denotes changing ideas of “nature”. The transition from manuscript copy to printed book, which became the copyists’ material for the first printed herbals (refer printed herbals Figure 1.07 and 1.08), had implications for the nature of scholarship and for the status of images.

Early manuscript book-making in Europe was initially undertaken in scholarly monasteries and the finest such as the Book of Durrow and Book of Kells in the eighth
and ninth century were intended to be church and royal treasures, symbolic artifacts, as the Codex Vindobonensis was for Anicia Juliana. Lengthy books were rare and the distinguished private library may have contained “a few dozen books” (Bishop 303).

The illustrations of the manuscript herbal of pre-Renaissance Europe need to be recognized within the context of the oral and manuscript tradition where books were supportive, rather than central, to acquiring knowledge. They were used to support learning taking place directly between master and student. When literature was heard or spoken, rather than read, the book functioned as a cryptic reminder of knowledge already acquired. By comparison, a contemporary twenty first century document is not a mnemonic but a definitive reference for visual identification of a specimen.

Apart from the traditional way illuminated manuscript books were used to support learning, the idea of literary property and copyright did not exist (Bishop 305). As discussed earlier with the example of the Codex Vindobonensis, visual textual accuracy was also affected by books being copies of much copied originals. The attitudes and practices of copy book-making were compounded by the fact that source documents, classical texts such as Materia Medica, contained descriptions of plants growing in the Mediterranean which could not be compared visually against a specific specimen.

As noted earlier in Rix (12), Dioscorides’ De Materia Medica was translated into Latin by the tenth century but the paintings attached to Codex Vindobonensis remained in Constantinople until 1569.

The limitations of the illustration in early manuscript copy for studying natural history became the basis for emblematic images in early printed herbals and were not without purpose. It is worth noting here that their decorative immersion in text had a continuity
(of authorship), the value of which had to be recognized and reestablished before copying with the new print technology became a significant tool in seventeenth and eighteenth century.

1.5 Style and “unnatural icons”: illuminated manuscript copy in early printed herbals

The early wood block printed herbals were characterized by the style of the copied painted manuscript tradition and its problems of inaccuracy, what Dickenson refers to as “corrupted and much copied illustrations” (81).

The earliest printers were trained in the manuscript tradition with which they were also competing. These early printed books, incanabula, resemble aspects of medieval manuscript book design and layout, as title pages and pagination were not included and there were spaces left for illuminating initials. In the Grete Herbal (discussed further in Chapter 3 Herbae nudae and icontype), the decorative foliage on the capitals and images of plants are boxed in, recalling the illuminated manuscript. Images were sometimes used interchangeably as substitutes and these functioned as a visual device to break up the dense blocks of text rather than correlate with the specific textual description. In addition to the vagaries of copying practices were the images of the plants which conveyed information as visual clues about specimens which were already known. The identification of these plants such as the mandrake (Figure 1.08) relied on additional knowledge and experience of it and the text, other than a comparative visual study. Rix (16) suggests they are so stylized that to the unfamiliar eye they are almost unrecognizable.

The scientist and historian Brian J Ford (in Dickenson 82) suggests in Images of Science: A History of Scientific Illustration (1992), that the persistence of “unnatural icons” and
inconsistent hand copying owed less to incompetence than to the protection and maintenance of “the arcane nature of knowledge”. The image serves as visual reference for other types of information, in some cases the effect of the herbs may be illustrated rather than showing the appearance of structure or form of a specimen. For example, Rix (16) cites the illustration of Narcissus, printed in Mainz by Jacob Meydenbach in Ortus Sanitatis (1491), where “little figures pop out of flowers” in an image of the plant subject that “has more to do with the youth of classical mythology than the flower that bears its name”. Blunt (59) describes it as “fanciful” and suggests the image would be “more at home among the nonsense botany of Edward Lear (Figure 1.07.b)

The botanical sections of Ortus Sanitatis 1491 (it also contained sections on animals and rocks) are “a German adaptation” of Peter Schoeffer’s 1485 German Herbarius, also known as “Herbarius zu Teutsh, the German Hortus Sanitatis or Cube’s Herbal” (Rix 16), which was itself a larger version of his own (Schoeffer’s) 1484 quarto volume the Latin Herbarius shown in Figure 1.07a.

Schoeffer’s 1485 German Herbarius, presents naturalistic representations of the daisy and the common polypody fern that correlate with observations and although as Blunt (57) states some “are unquestionably made from drawings of the living plant”, these “naturalistic drawings are alongside…many others which are scarcely better than those in the Latin Herbarius 1484; and the inevitable mandrake (Mandragora officinalis)”. Similarly, the anthropomorphic whimsical cartoon-like the mandrake (Figure 1.08) in Le Grand Herbier printed in Paris before 1522, is accompanied by the naturalistic images of grape vine and clover.

The coexistence of these contrary representations of nature within the herbals: the veracity of directly observed plant subjects (polypody, daisy) along with fantastic images of the mandrake or narcissus (in Figure 1.07b and 1.08), reflects an idea of
‘nature’ in Medieval times that is embodied in Dante’s circles. In Art and Beauty in the Middle Ages (1986), Umberto Eco (53) describes symbol and allegory as characterizing the Medieval understanding of the world.

“The Medievals inhabited a world filled with references, reminders and overtones of Divinity, manifestations of God in things. Nature spoke to them heraldically: lions or nut trees were more than they seemed; griffins were just as real as lions because, like them, they were signs of a higher truth.

In these early printed books, the image such as the mandrake can be a visual substitute for the unseen sample. With vagaries of nomenclature the images can illustrate or resemble the identifying name of the text rather than nature itself (Boas in Dickenson 82). In some cases the identity of name and image converge with the value of the sample. The image is a cryptic and symbolic way to depict the plant and the remedy. This is evident in the 1484 Latin Herbarius issued in a quarto size by Peter Schoeffer (refer Figure 1.07), which contains the “bold design of ‘Serpentaria’” (perhaps a plantain) —so called because it was thought to be effective for snake bites” (Rix 15). The woodcuts of the Grete Herball (1526) drew on the German Herbarius and other inacanbula, as did others published at this time. In his discussion of early printed herbals Wilfred Blunt (60) quotes the author of Hieronymus Braunschwig’s treatise on iDistillation (1500) who disregards the images as, “nothing more than a feast for the eyes, and the information of those who cannot read or write”. Despite the printed herbals’ popularity and their prevalence into the sixteenth century, they had limits for identification. The demands of the proto-Renaissance enlightenment required much more accurate representations.
1.6 Printed books and watercolours

The traditional technology of making books made from papyrus and parchment (prepared from animal skins) began to change in the twelfth century with increased availability of paper. There was a vast medieval literature and small Books of Hours, breviaries and schoolbooks were mass produced (Bishop 306).

Printing pictures in the mid fifteenth century “preceded books by several decades” (Gombrich 213), but it is the influence of printed books which radically altered the nature of scholarship and stimulated the exchange and comparison of information. In contrast to illuminated manuscripts such as the Codex that existed in what Dickenson describes as the oral manuscript culture, there was also a context where the book’s text and imagery were an aide-memoir for received wisdom. These printed books functioned more as a solitary silent teacher.

Dickenson (54) notes Elizabeth Eisenstein’s assessment of “the qualitative difference in the accuracy of sketchbook rendering — the manuscript — and the widespread dissemination of an accurate printed image”. Woodcuts (discussed further in Chapter 3) were appropriate for producing books where the images and text could be bound together, although Dickenson points to the fact that “it was rare that the original drawing and the woodcut were done by the same person”. This departure from the way images had been produced for the manuscript (by fewer people), “… led to a rupture in the web of meanings which had surrounded text and image in the hand-copied manuscript. […] Relationships between texts and illustrations, verbal description and image, were subject to complex transpositions and disruptions.” (65)

The dramatic increase in the scholarly textual exchange, related to Gutenberg and the technology of the printing press, stimulated the demand for images that required a new trust in the image. Students of nature and botanists supported the increasing
correspondence and written exchanges, using reference material of dry specimens, drawings and identifiable images in watercolour. Konrad Gesner’s (1516-1565) statement about the necessity of the coloured drawing, so that “students may more easily recognize objects that cannot very clearly be described in words”17, illustrates the significance of colour to communicate and confer value on images, and indicates new trust in the visual. (Refer to colour chapters 3 and 5)

Considering this changed attitude to nature and to images between the medieval and Renaissance sensibilities, Dickenson (47) acknowledges the renewed scientific revival of the sixteenth century and highlights the combination of new (print) technology and existing conventions in methods of image making. Regarding the latter, “paintings (of the fourteenth century) were often ‘built up’ by artists from drawings in sketchbooks or pattern books, …copied from medieval sources…[and] used by artists and illuminators, [and] embroiderers.” Of the sixteenth century, Dickenson (47) quotes Francis Klingender writing in Animals in Art and Thought to the End of the Middle Ages (1971), on the way in which the “scientifically controlled projection of a three dimensional world … came to be accepted in Europe … as the only mature mode of vision”. Dickenson clarifies this noting that, “Naturalism as a mode, however, was in the early period still a matter of details, of beautifully rendered flowers, or minutely portrayed insects, often set against a blank background.”

Dickenson (55) draws attention to the discrepancies of resolution between manuscript and printed images, and the way in which rendering conventions of perspective and colour used in the naturalistic watercolours of Durer (1471-1528), John White (c. 1540 – c. 1606) and Jacopo (Giacomo) Ligozzi (1547-1626) had been accepted by naturalists as “a simulacra of the real world”. Problems of poor resolution in the early woodcut prints allowed the watercolour to become established as the reliable method of direct observation, Dickenson (53) refers to the “flood of hand-painted images (chiefly
watercolour)”. “Collections of illustrations became in effect a portable museum and the accuracy of the image was trusted.”

This is clearly delineated in the accurate naturalistic representation of the Comfrey in Figure 1.09. The woodcut depicting Comfrey (Symphytum officinale) from Otto Blumfels Herbarum Vivae Eicones (1530) is the work of Albrecht Durer’s pupil Hans Weiditz (d. ca 1536), and it gives an indication of the change of attitude to images, their purpose and value. Although, as Dickenson (84) explains, there was lingering suspicion regarding the value of image as opposed to written description, the Weiditz illustrations showed the directness, immediacy and detail of observation of live specimens, and in the accuracy of information conveyed it was possible to regard the image as a substitute for the specimen itself.

The botanist Leonhard Fuchs’ (1501-1566) printed herbal, De Historia Stirpium (1542) that I discuss later in Chapter 3, is described by Dickenson as “a masterpiece”, and as “the high watermark of the Renaissance herbal” (Singer qtd. in Dickenson 84). The requirement of the image to be able to be independent of textual description is expressed by Fuchs himself:

“...it is the case that with many plants that no words can describe them so they can be recognized. If, however, they are held before the eyes in a picture, then they are understood immediately at first glance” (Fuchs qtd. in Dickenson 84).

The entire process of translating the drawing to the print was meticulously supervised by Fuchs, and his woodcuts were still being used well into the seventeenth century. His expectations of the image and its intention are expressed by his own words.
“As far as concerns the pictures themselves, each of which is positively delineated according to the features and likeness of the living plants, we have taken peculiar care that they should be most perfect; and moreover, we have devoted the greatest diligence to secure that every plant should be depicted with its own roots, stalks, leaves, flowers, seeds and fruits. Furthermore, we have purposefully and deliberately avoided the obliteration of the natural form of the plants by shadows, and other less necessary things, by which the delineators sometimes try to win artistic glory: and we have not allowed the craftsmen so to indulge their whims as to cause the drawing not to correspond accurately to the truth.....” (qtd. Dickenson 85).

Fuchs’s insistence on optical empirical clarity can be contrasted to illusionistic manuscripts images shown in Figure 1.10 and 1.11 that also show a new attitude to the study of plants and animals. Although depicting precise details and showing objects close to their actual size and as well as evidence of having been studied from nature (and are a departure from flourishes and interlacing ornamental borders of Gothic ornamentation), they use shadows and illusionist devices such as objects piercing the page or attached by threads and pins.

Fuchs’s aim and attitude anticipates the work of subsequent artists such as Maria Sibylla Merian’s Metamorphosis whose work revolutionized the study of botany and zoology, and contributed to the system of plant classification.

The increased amount of scholarship, linked to the technology of both print and optics contributed to the changed status of the visual representation of nature. A changing sensibility regarding objects of the natural world is explored further in Chapter 2 with my discussion of Maria Sibylla Merian and her life in the context of seventeenth
century Europe and the development of the work Metamorphosis Insectorum Surinamensis, published in 1705.

The transition from the Ortus Sanitatis (1491) with its crude and whimsical illustrations to the naturalism of Otto von Brunfels’ (1464-1534) Herbarum Vivae Icones (1530) was just forty years. The difference between these images exemplifies changes in their graphic language, and what Gombrich (in Art and Illusion) refers to as a shift between “universals and particulars” (137). Rix credits the period of forty years between these books as the transition between medieval herbalism and modern science. The differences between their purpose, graphic convention and their relationship to both print and ocular technologies are expounded in Chapter 3 “herbae nudae and Icontype”.

In this chapter I have traced the development of imagery in relation to changing knowledge of nature and books and woodblock printing. In Chapter 2 Metamorphosis I discuss sixteenth and seventh centuries developments and responses to the new worlds, of natural history and microscopy.
1 Any book printed before 1500
2 Theophrastus’ Historia de Plantis (History of Plants) or De Causis de physiological Plantarums (The Causes of Plants) considered changes in plants were natural not miraculous, and it recognised differences in plants reproduction. Food and drugs were the purpose of the Lyceum garden Athens, considered by some the first botanic garden. Alexander the Great sent samples from military expeditions in Indus River in India, 500-550 species and varieties of cultivated, wild plants not known and unnamed, but he was hampered by insufficient terminology and introduced new technical terms.
3 The range of plants Rix (8) refers to as “plant portraits” show “vines, papyrus, ears of wheat and barley, leaves of oak, ivy and olive as well as two medicinal herbs such as the giant fennel or silphion (Ferula chiliantha), from which the drug asafoetida was obtained”.
5 Cratevas (Krateuas) was botanist and physician to Mithridates VI Eupator, King of Pontus in Asia Minor cf. Collins English Dictionary 1979, p 944. “Mithridates VI or Mithradates VI n. Called the Great ?132-63 B.C., King of Pontus (?120-63) who waged three wars against Rome (88-84; 83-81; 74-64) and was finally defeated by Pompey: committed suicide.”
6 In The Art of Botanical Illustration (1981) Rix (10) describes that Dioscorides based Materia Medica on his own experience and the writings of others including Cratevas.
7 Quoting Karen Reed, Dickenson (81) states that Latin translations of Theophrastus, Pliny, Dioscorides and Galen were “all available in up-to-date printed editions” in the 1530s.
8 Anicia Juliana daughter of Flavius Anicius Olybrius (430-472) briefly in 472 the Western Roman Emperor.
9 Of two incomplete copies, just 142 plates were made by Nikolaus von Jacquin during the reign of Empress Maria Theresa (1717-1780), a Hapsburg influential in Vienna for 40 years. One was sent to Linnaeus and the other to Sibthorp for reference in his work with Ferdinand Bauer for Flora Graeca (1806 to 1840). The introduction to Flora Graeca acknowledges Dioscorides and Theophrastus.
10 In Naples Codex Neopolitanus an eighth century copy of the Vienna Codex and another “probable copy in Pierpoint Morgan Library New York”; a ninth century codex in Paris derived from a separate source and “several extant manuscripts in Arabic, some with reasonable illustrations” (Rix 12).
11 The trompe l’oeil illuminations of Georg Hoefnagel late sixteenth century Renaissance will be discussed in chapter 2 Metamorphosis.
12 Peter Schoeffer (c. 1425 – 1503) was a successor of Gutenberg in Mainz, who in 1455 testified for Johann Fust against Gutenberg.
13 Herbs2000.com describes Polypody (Polypodium vulgare) as a perennial fern growing to about 30cm, prized since ancient times for its medicinal powers. A sweet licorice-tasting rhizome (underground stem), preparations of it were prescribed by Greco-Roman antiquity physicians as a mild laxative, as a purgative and for coughs and chest complaints and it was well regarded. <http://www.herbs2000.com/> The fern belongs to the family Polypodiacae, [15th century: from Latin polypodium, from Greek, from POLY + pous foot]. The word “Polypody” alludes to the many footed appearance of the branching rhizomes. cf. Collins English Dictionary 1979, p 1137.
14 The rarity of books changed after improvements in the method and manufacture of parchment paper and book-making proliferated. Bishop (303) describes the emergence of professional copyists associated with universities and the fact of one fifteenth century Florentine bookseller whose clients included Cosimo de’ Medici employing forty-five copyists.
15 Folk epics were written down and vernacular literatures competed with Latin that became the preserve of the educated.
16 The issues of print technology and its implications for reproduction and authenticity will be discussed in subsequent chapters. Dickenson (55) identifies three issues central to the development of early printing and image resolution, “(the) technology of printing and colouring; the conventions of the engravers and cutters; and the relationship of the printed image to the text.”
17 Quoted in Dickenson (52).
18 Used in Johnson’s 1636 Gerard’s Herball and in Flemish Herbal of Robert Dodoen 1517-1585. Dodoen is one of three great Dutch Flemish botanists of second half of sixteenth century; the others were Carolus Clusius 1526-1609 and Mathias Loblius 1538-1616.
Founded in 1545 at Padua University's Faculty of Medicine the “Giardino dei Semplici” i.e., the remedies directly obtained from nature, is regarded as the earliest university gardens. (Among its rare plants was the palma tree planted in 1585 that attracted Goethe when he visited the garden.) These gardens were accompanied by a hortus siccus, the dried garden, or what we know as the herbarium.

Antoni von Leeuwenhoek (1632-1723) developed the microscope lens in Holland in the sixteenth century and Robert Hooke's Micrographia dates from 1664.

The extent of “nature” in the New World through the voyages of discovery were exemplified by Columbus's three voyages of the 1490s, and Thomas da Costa Kaufmann’s distinction between the philosophical and religious differences in the representation of nature in the books of hours of “Ghent Bruges” manuscripts and those of the stammbücher and trompe l’œil of Georg Hoefnagel in the essay “The sanctification of nature”, The Mastery of Nature (1993).
Chapter 2  A Metamorphosis New Worlds - trust and truth

Introduction

“For people find it more agreeable to sit listening in lecture theaters than to go into lonely places searching for plants at the appropriate season” Pliny the Elder’s first century AD Historia Naturalis: A Selection (qtd. in Dickenson 256).1

Pliny’s insistence of the value of first-hand observation and field-work experience underlies a part of the solution to the problem of inaccurate copies and questionable vicarious representations of nature. This chapter explores the shift from the vagaries of botanical representation in oral-visual manuscript documents to the empiricism of Maria Sibylla Merian’s (1647-1717) Metamorphosis Insectorum Surinamensium (The transformation of the insects of Surinam). It outlines Merian’s role in establishing criteria and conventions for subsequent artists and scientists representing nature and the development of the sciences of botany, entomology and taxonomy. This study also recognizes the implications of technology in the relationship between observation, visualization and representation.

Merian’s observations and specialist knowledge of nature particularly of butterflies and moths (Lepidoptera), combined with her expertise and use of new technology is relevant to contemporary readings of the relationship between digital imaging technology, the visualization of knowledge and art practices. Examining specific images from the seventeenth century within a framework of chronology, context, and purpose provides the frame of reference for subsequent research of the visual inventory in a digital environment.
The biographical context of Merian’s life and the influences that inform her work is a combination of these factors together with her specific personal interests and skills. Known and acknowledged in her twenties as an artist\(^3\) (Davis141) and referred to now as an artist and entomologist, Merian worked in a period of transition, between the multi-disciplined non-specialist and the development of Cartesian science underpinned by dualistic philosophy and increasingly specialized practitioners. Observation and representation in twenty-first century contemporary digital imaging technology mirrors a similarly radical shift in the hegemony of textual and visual knowledge and has implications for the boundaries between contemporary specialist practice in art and science.

Maria Sibylla Merian (1647-1717) is renowned for her works as an independent artist, entomologist and businesswoman. Her extraordinary voyage with her adult daughter to Surinam in the Indies in 1699, where in two years she produced 63 watercolours, was an outstanding journey. Merian’s particular significance for science resulted from her publication of these watercolours in the book of engravings *Metamorphosis Insectorum Surinamensium*. At the time of publication in 1705 the accuracy of her (written and visual) descriptions of observations of natural phenomena were a radical departure from previous representations of nature. Linnaeus refers to Merian’s work over one hundred times and her drawings and printed work became the benchmark for subsequent artists in their task of representing the nature of the New World (Dickenson 148).
2.1 Merian and mid-seventeenth century Europe.

Maria Sibylla Merian’s birth in 1647 in Germany to a Dutch mother and a Swiss father after the Reformation is on the cusp of major cultural, social, economic and ideological changes in Europe. Within Merian’s lifetime René Descartes’ (1596-1650) philosophical work was being absorbed and Isaac Newton published Principia Mathematica (1687). It was the beginning of a period of 300 years of development in science when ideas and motivation for the depiction of nature were being redefined.

The art historian Thomas Da Costa Kaufmann explains the way in which the tromp l’oeil nature studies in the Stammbuchlättler of the artist-empiricist Georg Hoefnegal’s and Ghent-Bruges manuscripts religious Books of Hours (refer Figure 1.10 and 1.11), linked the religious and profane and indicate a shift towards “the de-sanctification of nature”. Kaufman interprets the private indulgence of the tromp l’oeil effects and decorative margins of these late sixteenth century Netherlandish illuminated books to changes in attitudes, and they “suggest how motivations related to religious beliefs and practices may have contributed to the creation of illusionistic imitations of the natural world.”

Merian’s life coincided with the significant developments in optics. In his study of the development of scientific instruments the mathematician and anthropologist, Thomas Crump suggests that the invention of the telescope and Galileo’s observations in the early seventeenth century, “soon led to the idea that a similar instrument could be used to examine, in unprecedented detail, objects close to the observer. This explains the origins of the microscope, [which has become] in the last four centuries the most versatile and widely used of all scientific instruments.” (57)
Crump (59) attributes the first microscope to Dutch inventors around 1620, and while he acknowledges the respective work of the Dutch scientist Christiaan Huygens (1620-93) and the Englishman Robert Hook (1635-1703) on compound microscopes, he credits the Dutch linen merchant-haberdasher Anton van Leeuwenhoek (1632-1723) as “undoubtedly the master: [whose] observations [using small single lens microscopes] transformed plant and animal physiology”.

The artistic influences on Merian outlined in this chapter derive from her immediate family and their connection to this wider context of contemporary culture in seventeenth century Europe. In the context of botanical events, her birth occurs a century after the establishment of the Giardino dei Semplici Orto Botanica (1545), Padova, and just a decade after the peak of Tulipomania in Holland.

2.2 Use, Beauty and a collectable aesthetic.

The local economic impact of Tulipomania (economic phenomena or aberration) and the craze specifically for tulips had peaked in Amsterdam by 1637 and it was succeeded in the United Provinces by a interest in the hyacinth, another craze which extended throughout Merian’s lifetime and until the 1730s (Dash 248). The Tulipomania phenomena reflected the different consciousness about “nature” and attitudes to plants that was a departure from earlier attitudes to nature and plants restricted to medicinal use. Nature became a collectable aesthetic commodity that was reflected in the status of both art and botany. The market for bulbs and blooms was accompanied by a market for the art of Dutch flower painters, and similarly, it stimulated the cultivation of unusual plants and gardens as status symbols displaying the wealth and good taste of their owners. A response to nature spread through the
“Golden Age”, when culture, trade, art and science flourished, and that the United Provinces (or Dutch Republic) enjoyed between 1600 and 1670 (Dash 83).

The development of the flower gardens in the early seventeenth century saw the emergence of florists as specialists in plant cultivation and the appearance of the first Florilegium. The observation and precision of cultivated plants depicted in the florilegium and the seventeenth century Dutch flower painters such as Jacob Marrell (1614-1650) Figure 2.01 contrasts with the simplicity of images of plants produced in the herbal tradition discussed earlier (shown in Figures 1.09 or 1.10). As albums for collectors to admire, compare and contemplate the potential of their gardens, the florilegia confirm the popularization of plants for their beauty as well as for their usefulness.

### 2.3 Reconciling the exotic New World

While the tulip, hyacinth and other popular blooms were brought to Europe from Central Asia, Turkey and the Ottoman Empire there was a growing awareness of the voyages west. The extraordinary flora and fauna from the Indies, Central and South America were becoming known in Europe throughout the sixteenth century and this supplemented an increasing curiosity and desire for the unusual.

“In 1520, the treasures of Montezuma were on display in Europe, and that glittering horde fixed the image of America as strange, rich and exotic, full of peculiar beasts and wonderful plants.” (21)

Dickenson’s description gives an indication of the nature of an early contemporary awareness of the New World which prevailed through the sixteenth century and which in the seventeenth century was significant for Merian’s art and science. In his essay “Early European Images of America: the ethnographic approach”, Massing (514-519) discusses the limitations of the early European observers’ frame of reference for
understanding the strange and new. Although sympathetic observers of the artifacts from these new cultures, the European sensibility and experience was reflected in the detail of Durer and Burghmair’s interpretation of weapons and garments. Massing describes how “[...] artifacts are rendered more or less exactly but often without a proper awareness of their function. The effect is often composite, a mixture of elements from different cultural contexts” (517).

As Davies describes, “They sailed for reasons of trade, of loot, of conquest and increasingly of religion,” (511) and in considering the influence on Merian’s work the voyages of the sixteenth and seventeenth century can be seen to have stimulated a general awareness of the scale and exoticism of flora and fauna existing beyond the immediate European environment. The influence of these voyages on the work of her father Mattheus Merian (1593-1650) is discussed below, and they ultimately provided the opportunity for Merian to undertake her major work in Suriname.

2.4 Catalogues (of nature).

In Women Art and Society 1996, Whitney Chadwick (134) claimed Merian’s direct artistic legacy “derived almost entirely from the great flower painters of seventeenth-century Holland” and although this statement describes her painting technique, other factors discussed here contribute to distinguish her work as significant for entomology and botany. The influences, which derive from her father Mattheus Merian and stepfather Jacob Marrell (1613-1681) and their respective artistic work, synthesize with her own special interests in the mature work of Mertamorphosis Insectorum Surinamensis 1705.

Merian’s father and step-father’s work of the first half of the seventeenth century reflect different rationales governing the representation of nature, and the attempts by
Europeans to resolve rapid cultural changes. For Merian, the two versions of “nature” in her father and stepfather’s work (of prints and paintings) reflected a transition between representations that service the inner eye of imagination and the soul, and “new observations” that depicted an external world of places and creatures.

2.5 Interior world of Dutch flower painters.

Merian was taught the techniques of Dutch flower painters by her stepfather Jacob Marrell and early in life worked with Abraham Mignon (1640-1679). In 1664, Merian was a student of Andreas Gaff (1637-1701) whom she married. The work of Marrell and Mignon (Figure 2.01 and 2.02) are characteristic of the aesthetic of the Dutch still life painting, which in The Story of Art Gombrich (341) describes as indulgence in the “sheer beauty of the visible world”. Gombrich is referring to the special concern with “light, colour harmonies, contrast and texture” and the repeated subject matter of still life arrangements which offered “a wonderful field of experiment for the (specialist) painters’ special problems” (340)). The repetition of still life subject and specialization in this genre suggests to Gombrich an ambiguity that also denies the importance of subject matter, “It (Dutch still life painting) ended by proving that subject-matter was of secondary importance” (341). The paintings are assemblages of accurate, meticulous observation and technical execution of the display of “impossible” nature. As a vehicle for their expertise, the artists assembled lively specimens in their floral compositions, distinctly different seasons all flourishing and blooming simultaneously. In one sense this was a catalogue of the scope and variety nature offered, as well as a palatable form for presenting reminders of transience and mortality. The symbolic insects, permanent blooms, flowers and fruits served to illustrate the metaphysical.

Although Dutch flower painters had inherited much of the illusionist trompe l’œil devices of Georg Hoefnagel’s (1590s) Stammbuch illumination (Figure 2.03.) and their
art reflected a changing attitude to nature and new fascination with observation, nature's possibilities and variety is essentially used as a symbolic pattern book. Life, death, mortality were portrayed and the winged insects were symbols of the human soul or alternately, as Hall describes, served (126) as "protective talisman".

2.6 Nature bound and dressed.

Merian's earliest works were copperplates published in 1675 and 1677 as *Florum Fasciculi tres* and later in 1680, republished together as hand coloured engravings known as the *Neues Blumen Buch* (New Flower Book), referred to Matthaeus Merian's work in de Bury's *Florilegium* (Chadwick 136). The garden flowers (as in Figure 2.04) tied sometimes with ribbon, show Merian's observation and painting skill and they are, as Chadwick describes, delicate and intricate. Merian taught embroidery and these books were used as patterns by embroiderers. This purpose was evident in the decorative design rather than descriptive quality of this work. The presences of insects were imprints of the aesthetic of the time (of the Dutch flower painter) and in their details the designs spoke of the value and virtue in the embroiderer's industrious labor. As Chadwick (129) describes, the momentary significance of gender was also important to the developing visualization of phenomena.

"Throughout the seventeenth century, painting served both domestic and scientific ends that which was accurately observed pleased the eye and in turn confirmed the wisdom and plan of God. Science and art met in this period of flower painting and botanical illustration. The task of describing minute nature required the same qualities of diligence, patience, and manual dexterity that are often used to denigrate "women's work". Women were, in fact, critical to the development of the floral still-life, a genre highly esteemed in the seventeenth century but, by the nineteenth, dismissed as an inferior one ideally suited to the limited talents of women amateurs."
2.7 Visualizing new worlds

Merian's father was the engraver Matthaeus Merian (1593-1650) who undertook work for Johann Theodore de Bury and although her father died when she was a child, Merian was closely linked to de Bury's florilegium and to some of the earliest images of what was still the strange New World. His influence can be described by his attempts to overcome the problem of accommodating and reconciling others' observations in the absence of experience.

The cartoon character of the weird and wonderful beasts in Matthaeus Merian's landscape Figure 2.05 was due in part to their invention and construction from a range of sources, and the practices of artists using new print technology. Eyewitness accounts transferred through numerous verbal accounts and some visual interpretations were a common practice. Dürer's enduring rhinoceros is a typical
example of the authority gained by an image from a secondhand source and the practice of reinterpretation and copying of the early print technology. Disconnected and rejoined, the descriptions of the New World were sourced from written translations, visual and verbal descriptions of skins and recopied woodblocks and inter-changeable engraving plates.

Dickenson tracks the reoccurrence of the “emblematic” animals such as the “su” and the “opossums” and the “simpivulpa”, and the incongruity of the verbal and visual, in her discussion of New World Landscape (37). Within one frame Matthaeus Merian’s view was all encompassing. Just as the Dutch flower painter’s version of nature could assemble the seasons simultaneously, Merian included a full line-up of creatures and landscape features. Artists were representing the unfamiliar, unimaginable and unseen. Solving the problem of showing this information resulted in a collage of fact and invention. This convention (of assembling and relating images and simultaneously constructing scenarios), persisted in museum dioramas and it still occurs in the digital reconstruction and special effects technology that present prehistoric creatures and their environments, such as the Ornithocheirus featured in the BBC’s program Walking with Dinosaurs, and in films such as Jurassic Park.

2.8 Revealing nature.

Of the first of the three volumes of her own engravings which Merian published in 1679 the title alone indicates the extent of her departure from her father’s collage of nature and the influence of the Dutch Flower painters. Der Raupen wunderbare Verandelung und sonderbare Blumenahrung (The Wonderful Transformation of Caterpillars and Their Singular Plant Nourishment) was a radical document in its representation of 186 European plants and insects together.
In this work Merian’s interest was in showing the entire process of transformation of butterflies and moths (eggs, larva, pupa, and imago), and she based her images on direct observation of the specimens she collected and bred and the plant as food source. Her curiosity about Lepidoptera may have been influenced by familiarity with Jan Jonstons’10 (1603-1676) *Natural History of Insects Historiae naturalis de insectus*, engraved by her half-brothers in 1653 and published by the Merians. Merian’s stepfather Jacob Marrel included numerous butterflies, caterpillars and insects in his paintings of flowers and he might have referred to real specimens in the studio or painted them from life. In addition to this, his brother was involved in the Frankfurt silk trade with ready access to those who handled silkworms and Davis suggests that together these things contributed to the particular development of Merian’s interest in insects and her skills as a painter and printmaker. (143)

The research and direct observation of this work and its reception within the scientific community announced Merian as an entomologist as well as an artist (Chadwick 36). These winged insects were not the symbolic creatures of allegorical Dutch and Flemish still-life painting mentioned earlier. In this work Merian removes the ribbons that were present in the *Neues Blumen Buch* and reinstated nature as the central subject.

The images in *Der Raupen wunderbare Verandelung und sonderbare Blumenahrung* were not constructions of nature to reflect, declare or warn of the moral values of the time. Merian’s account of nature was unlike either of her father’s versions of nature, which had been considered to be ‘drawn from life’. By contrast these were arrived at by direct observation, not through the glass of the collector’s cabinet, or collated from a range of vicarious descriptions. Merian’s own description of her method in the preface of the first edition *Metamorphosis Insectorum Surinamensium*, stated “...there I
brought these sixty drawings with the corresponding observations, painted on vellum directly from life."

Appreciating Merian’s subject matter, the newness of the material in the seventeenth century, the botanist and author David Bellamy11 (b.1933-) noted that the development of insects from eggs rather than mud had only within “a few decades been conclusively demonstrated”. Merian’s process was central to the significance of her oeuvre.

“From my youth I have been interested in insects, first I started with the silkworms in my native Frankfurt-am-Main. After that...I started to collect all the caterpillars I could find to observe their changes...and painted them carefully on parchment.” (qtd. Chadwick 136.)

This work is the beginning of the work for which Merian is most renowned, the *Metamorphosis Insectorum Surinamensium*, and together these images of European and South American plants and insects “helped lay the foundations for the classification of plant and animal species made by Charles Linnaeus later in the eighteenth century” (Chadwick 136).

Merian applied the precise observational method and technique of the flower painters and gazed at nature for the value of the wonder it offers. The image and subject were one and the same, reconciled in what had become recognized visual conventions for (science and art of) botanical illustration.

Merian’s circumstances continued to contribute12 to the development of her work; she was in contact with both, Casper Commelin (1668-1731) botanist and head of the
botanical garden in Amsterdam, and with Antonie van Leeuwenhoek (1632-1723) researcher and inventor of the microscope. The curiosity and fascination with the extraordinary was stimulated further by access to Waltha Castle and Cornelis van Arsen van Sommelsdijk’s private collection of natural objects from the Netherlands’s overseas colonies. It included insects from Surinam, where van Sommerlsdijk had been the Governor, and the colour, form and size of these specimens was a dramatic contrast to the European insects with which Merian was familiar. With the flora and fauna of this tropical county yet to be explored Merian obtained a stipend from the Dutch Government and traveled to Paramaribo, Surinam in 1699.

2.9 A dynamic symbiotic microcosm

In Figure 2.06 Merian showed nature as a dynamic microcosm, revealing the fundamental symbiosis of insects and plants. Every stage of the insect’s life cycle was represented in relation to the host food plant. This account was not of an idealized or pristine nature as seen in examples of her earlier work. Embodied in the transience and metamorphosis of butterflies and moths was the corruption of the supporting host plant. These plants were being consumed, chewed and ravaged by the process of transformation demonstrated in her paintings.

Merian’s visual account of nature was supported by her own notes of recorded field observation. The notes verified her witness to the events of insect life on the palisade tree (shown in Figure 2.06.) “…on 14th April 1700 they turned into chrysalises; on 12th June moths emerged”. This was supplemented with other general information that would assist plant identification and knowledge of its uses and value. In this instance (of the Palisade tree), when the yellow flowers faded the branches turned upwards and
she noted the similarity of seed pods of the tree to barley, and that its timber was used by the natives of Surinam to build their houses.

In Figure 2.07 which shows the ‘Peacock Flower’, Merian described the “medicinal” use of the seeds of this tree which could be ground up and eaten by Native Indian women once they were in labor to induce a birth, but were also used by “the Indians who were not well treated when in service to the Dutch, [to] take the seeds to abort their babies, so that their children are not born into slavery.”

The months of observation were recorded in sketches and studies that were later worked up into finished watercolours and it is likely that Merian duplicated them, aware of their commercial value to the demands of collectors. There is a set of the European and Suriname sketchbooks in The British Museum and Morton (1) refers to the set in Royal Library Windsor (which were purchased by King George III 1738-1820 five years before he came to the throne in 1760). Though creating an accurate reliable reference for the identification of specimens, Merian’s notes acknowledged the use of some secondhand accounts and these may be responsible for some inaccurate identifications which writers such as Davis and Owens have described. Annotations have been added to a number of botanical inaccuracies in Merian’s sketchbooks I examined in the British Museum.

2.10 The legacy of the copy (published engravings)

After returning to Amsterdam Merian financed the publication of Metamorphosis Insectorum Surinamensium by subscription (approximately 200 copies). A skilled engraver herself, she supervised three engravers to undertake this work (a vigilance reminiscent of Fuchs) and wrote up accompanying notes. The intention of these was clarified in this extract of her correspondence.
“the text of the book, as in that on the anatomy of [...] by Professor Bidloo [Bidloo, Atonmia humani Corpus, 1685] I have inserted on one sheet between two illustrations. I could have made the text much longer but because the world today is very sensitive and the learned differ in their opinion, I have kept simply to my observations. In doing so I provide the material for each individual to draw his own conclusions according to his own understanding and opinion, which he can then evaluate according to his own judgment: this approach has however been used extensively by others such as Mouffet, Goedart, Suammerdam, Blankaart and others. I have called the first transformation of all insects chrysalises.” (40)

The fact of the substantial correlation between text and image is significant for the way it underpins their value to natural sciences of the time. As with later artists who inherited her methodology such as Ehret, the purpose and function of the accompanying text is intended for a specialized audience of collectors and natural historians. Merian knew well the demand for the new material of her books and the intention governing these images was the curiosity and further knowledge of nature, rather than singular aesthetic gratification.

Chadwick describes Metamorphosis Insectorum Surinamensium as “magnificent” (136). A seminal work, its translations include Dutch and Latin, and its significance for scientists and artists has been outlined earlier. Johannes Oosterwyk, the Amsterdam publisher purchased all her pictures, plates and texts after her death and continued its publication.
The existing copies of Merian’s book show the role of the medium and the nature of a new technology that synthesised new technical and artistic and scientific conventions. The verisimilitude of the image is central to its value and significance.

In their comprehensive history of botanical art, *The Art of Botanical Illustration* (1950), the writers Wilfred Blunt and William T. Stearn remarked on Merian and the engraving process. “Characteristics of her style are the use of fine line work to facilitate the task of the engraver; a preference for transparent colour, sometimes rather gummy in quality; and a habit of using an intenser colour rather than the more neutral tone in her shadows.” (145)

In natural history, colour, as Dickenson (57) stresses, is “not trivial”, and discrepancies between printed copies can be attributed to technical factors in the process of printmaking. In the engraving process there are variables, such as the instability of pigment colour, the bias of the technician in mixing of batches of ink, the quality of pigment, variation in the skills of the cutters, printers and with inking and wiping plates. Where artists such as Fuchs, Merian and later Catsby (1682/3-1749) supervised or undertook the colouring of prints they were still subject to the physical vagaries of the media and its conventions, an issue which persists for contemporary printmakers using digital media.

Comparison of Merian’s prints alongside the watercolour shows noticeable differences attributable to the properties of different media (refer Figures 2.10 and 2.11). In the process of transition to print media the drawing and watercolours (gouache/bodycolour) on vellum became ink and watercolour on paper, and the reversal of the original into its mirror image in the engraved copy. The colour of the image on vellum (even after 300 years) offered a luminosity and freshness which is
similar to a transparency in a back-lit light box today. Much of the ephemeral liveliness and lightness of the colour on vellum was lost in the engraving, and instead in the black lines of the plate the image offered an authoritative permanence.

The engravings show additions, alterations and “corrections”. Differences are particularly obvious in the second image in *Metamorphosis Insectorum Surinamensis* of the ripe pineapple (*Anas comosus*) refer Figure 2.09 Ripe Annas. There are colour variations between them, in the former the pineapple leaves are light and sun bleached with a hint of grey-green; the engraving shows them a darker blue green. In the engraving the position of the butterfly was altered, and it had the addition of a flying beetle in the top right corner. A similar comparison can be made between the characteristics of the watercolour sketch Figure 2.10 Vine branch and black grapes, with moth, caterpillar and chrysalis of gaudy sphinx and the engraved copy of the same image in Figure 2.11.

As well as (its) visual accuracy (of resembling the specimen), Merian’s work confirms a particular set of spatial conventions and the value of the image depends on their recognition. When we see Merian’s plants and insects we understand the space of the page required to read the image and without hesitation know that these are specimens, what Gombrich refers to as “the conditions of illusion” (*Art and Illusion* 193).

Merian’s contribution to zoology, botany, taxonomy and the development of an accurate visual inventory of nature marked the beginning of the new value of truth and trust in images. This is the descriptive phase of natural science analyzed by Bernard Smith in *European Vision and the South Pacific*, in which he describes over a period of three hundred years, “the assembling of a systematic, empirical, and faithful graphic
account of all the principal kinds of rocks, plants, animals, and the peoples of the world” (339).

The role of empirical record keeping, classification, identification and communication of visual truth by botanical, topographical artists was central to the development of Enlightenment science. The representation of nature between the sixteenth and nineteenth centuries and its visualization in the plethora of print and illustration, have been marginalized in the glare of eighteenth and nineteenth century landscape painting and photography’s response to the sublime. In his 1992 essay *Mirror and Map*, Gombrich (188) highlights the different spaces occupied by media, devices, and styles and “the need to clearly understand the dominant purpose they are intended to serve.” Misapprehending the complex relationship between images, visual knowledge and technology underpins the schism of seeing and knowing.

In addition to the technological development of printing discussed here and in the next chapter, the developments in optics and microscopy contributed to the challenge of comprehending the credibility of images.

2.11 Spontaneous generation: the paradox of microscopy, comprehension and credibility of new New Vistas.

“I can’t wonder at it ... since ‘tis difficult to comprehend such things without getting a sight of ‘em.”

Anton van Leeuwenhoek (1632-1723) qtd. in Nabors 28

Before the microscope which was pioneered by Dutch spectacle makers Hans & Zacharias Janssen 1590 (Davidson. Molecular Expressions) and developed by Anton van
Leeuwenhoek, it was thought that small insects, fleas and grubs developed spontaneously from dust or mud (refer Chapter 2.7 Visualizing New Worlds).

In his study of the history of science through the development of scientific instruments the scientist and historian, Thomas Crump (2001) has described the seventeenth century developments in optics – the microscope and telescope, as “decisive” for science. He credits the microscope as being, “…. [in the last four centuries] the most versatile and widely used of all scientific instruments” (57), but qualifies this, stating that the microscope did not “come into its own until the nineteenth century”(xvi)17.

Anton van Leeuwenhoek’s difficulty in the seventeenth century, to reconcile what could be observed through the new instruments with what was expected or imagined, encapsulates something of the inherent contradictions Crump is referring to when describing the significance of early microscopes. However, the potential for observing the microscopic dimension and its technical limitations, mediated the immediate significance of the new instruments for artists and scientists who were endeavoring to catalogue and describe the expanding volume of material from the New World.

2.12 Disrupting the decontextualized space: a new graphic language

“…. [C12: from Medieval Latin cella monk’s cell, from Latin: room, storeroom related to Latin cellare to hide]” Collins English Dictionary 243.

Cells had been observed by Anton van Leeuwenhoek and Robert Hooke (1635-1703) in the seventeenth century, and named and drawn by Hooke (Figure 2.12) in his book Micrographia (small drawings) 1664.
Describing the significance of images in Robert Hooke’s *Micrographia*, the art historian Victoria Dickenson (231) quotes Dennis, “Hooke and other members of the Royal Society saw representation itself as an hermeneutic. For Hooke, ‘seeing and representing was understanding.’ Thus the plates in *Micrographia* were central, rather than supplementary elements in the book”. Hooke’s illustration of an image of cells of a Cork tree was accompanied by a drawing of the specimen seen with the naked eye. The microscopic view dominated the top two thirds of the page layout, and below this was shown the branch of the Cork plant. Each one is labeled respectively Fig. 1 and Fig. 2. For the viewer the combination of extremely different versions of the subject approaches “the distinctly double edged sword” of naturalistic representation. An imaginary animal can be depicted with a credibility no less sharp than an existing one”.

In his drawing shown (Figure 2.11) Hook includes the microscope itself and presents two different samples of cells. A black circular (lens) shape boldly states this microscopic resolution, framing and serving as background to the cell images in Fig. 1. Floating against this dark background are two irregular, semi-transparent shapes that touch the sides of the frame. Each shape resembles a torn ragged fragment of formless cloth; and is defined and distinguished by its linear white cell walls. The cellular structure of the elongated shape at the left is a grid, a web of rectangular shaped cells. In contrast, the cells of the shape on the right side look like the small circular holes found in a rounded sponge or pumice stone. Over each specimen vertical banding is shown with a tonal range varying from grey to black. In both cell specimens the spaces within the cells are a negative void.

Relegated to the much smaller space at the bottom of the page, Hooke offers identity and meaning to the cells by presenting a drawing of the whole plant. The section of
cork branch is prostrate on the white background below the dominant black disc. Each section of this specimen is labeled - “A Branch”, “A Sprout”, “A Sprig Closed”, and an open sprig is shown with a symmetrical arrangement of the leaves figured a - n. The branch, stem and leaves showing the form and shape in three dimensions have reverted to the familiar graphic language of volume, texture and tone, with the white background a complete contrast to the flat black disk above containing the patterns of cells. What is not clear from the entire image is that the microscopic image is only of the bark layer.

Hooke’s plate, with its contrasting views of the one subject, presages the disruption of the new technology and the disjuncture between visual experience and image. Stafford describes the divergence further.

“The microscope subverted the norm of lucid, coherent, and stable bodies. While this popular instrument transformed ordinary items, such as Robert Hooke’s cork cells, into mysterious and beguiling images it could easily explode attractive forms into repugnant or non-resembling patterns. The equivocal nature of information gleaned from optical apparatus, rendering the insignificant significant and the worthwhile worthless, also reveals how easily the observer’s perception might become confused. What appeared clear and distinct to the naked eye was exposed as chaotic or flawed under the lens.” (148)

2.13 Vision & limits of the retina

"More than half the human brain is concerned with the reception and processing of visual stimuli. With such an emphasis on sight it is no wonder that we say that seeing is believing." Gunning (1)
Although vision is regarded as the most reliable sense, paradoxically every optical device shows it is also the sense that most deludes. Discussing the history of optics and the impact of the microscope in 2007, the science historian Simon Schaffer highlighted the point that it “raised the question of how much you can rely on your senses, – on what you can see”. The relationship between the physiological limits of vision (the retina), and developments in science are explained by Crump (3).

“...the inherent nature of the retina imposes two severe limitations on the power of observation”. Until the significant developments in microscopes in the nineteenth century took place the “scientific insight” was determined by human physiology and the limits of the retina. The level of resolution possible with the retina is a barrier to the “observation of micro-phenomena, and the discrete pulses of neural signals prohibited the direct observation of ...phenomena that are too transitory.” In order for “any phenomena to be visible (it) must last for a finite time – measured in milliseconds.” Crump (3-4)

Acknowledging the existence of these incredible microscopic resolutions challenged the existing understanding of the parameters of visual perception and experience, and the regard for known phenomena. The response to viewing things that could not be calibrated in this microscopic world evokes the fantastic experiences recorded in textual and visual accounts of natural phenomena that resulted from voyages of discovery to the New World. The strange otherness of these new microscopic observations recalls Matthaeus Merian’s image of New World landscape (Figure 2.05), as he and other artists had attempted to find a new visual language to interpret the textual accounts of flora and fauna in these other territories.
Anton van Leeuwenhoek (1632-1723) observed “little animals” in soil and sour milk - what we now call microbes. The small simple single-lens microscopes he had crafted himself were like a magnifying glass and they are significant because they magnified without distortion20 (Nabors 28). Anton van Leeuwenhoek’s contemporary Robert Hooke (1635-1703) confirmed his observations in 1677 using a more powerful compound microscope, a tube shaped microscope with three lenses that magnified up to 470X (Mason 147). Though Hook’s microscope was comprised of more than one lens that - “did indeed magnify, ... they also distorted, and the addition of a second lens simply magnified the distortion.” (Nabors 28).

The developments in optics in sixteenth and seventeenth centuries revised the existing relationship between visual and textual accounts of observed phenomena. As Crump (45) describes this shift “...until the dawn of modern science) almost any phenomenon reported in speech must originally have been observed, or at least have been capable of being observed by the human eye.” Until the technical developments of the nineteenth century and the “scientific insight” (Crump) that these improvements brought about, the effect of optical technology on botany was limited. In her study of the significance of images visualization and optical technology, Good Looking: essays on the virtue of images (1996), art historian Barbara Maria Stafford describes the way these instruments were regarded (in the seventeenth and eighteenth century). 21

“Microscopic images belonged to a new and amusing sensory technology dedicated to the creation of optical illusions that strained credibility. Magnifications joined sorcerers’ mirrors, concealed magic lanterns, and machines for projecting phantoms on smoke in making things appear as they were not.” 149
2.14 The Microscopic sensibility

Despite its optical limitations the development of the microscope created awareness for artists and scientists of the miniscule, and generated a consciousness of the merit of calibrating visual experiences. Within decades of Anton van Leeuwenhoek’s observations and the new knowledge “that insects developed from eggs, not from mud” (Bellamy 8), Maria Sibylla Merian’s observation of her subjects resonate with this microscopic sensibility. Although she “seems to have used only a magnifying glass” (Davis 151), Merian’s plant and insect subjects in *Metamorphosis Insectorum Surinamensium* show surface appearance, form and texture as well as visualizations of their changes through time. The attention to detail, clarity, and visual accuracy of her observations in image and texts (and that Linnaeus and others noted), were created in an intellectual context that placed increasing significance on defining and scrutinizing phenomena and the merit of visual accounts. I have described here the Merian’s vision and the new optical aesthetic and the influence of these things is reflected in the images plants in the eighteenth and nineteenth century botanical treatises discussed in the following chapter.

2. Three areas outlined by Dickenson as necessary for the study of representation.

3. By the age of 28 Merian was recognized as an artist and included in Joachim Sandart's (1606-1688) history of German art, *German Academy* (1675-1679).

4. At this time there was the reformation division of Europe into Catholic and Protestant; the effect of technology of printing, and the voyages of discovery of a New World.

5. Hook's *Micrographia* was published 1665 and it is possible that a copy would have been seen by Anton van Leeuwenhoek (1632-1723) when he visited London in 1668. Anton van Leeuwenhoek was familiar with magnifying glasses because at age 16 he worked in Amsterdam as an apprentice and bookkeeper to a Scottish textile merchant and magnifying glasses were used to count thread densities for quality control purposes.

6. While Dickenson (22) describes the mixing in the public imagination of tropical America, the Indies of the New World, with its descriptions of the people of Calicut with the Old World Asiatic India, Massing (516) explains that as America was thought to be part of Asia the term Calicut was as a generic term for inhabitants for all newly discovered lands. This idea was maintained until after Magellan's circumnavigation of the world in 1521.

7. Hall (126) describes insects such as the Fly in sixteenth century Netherlands painting as "the protective talisman against real insects which might otherwise settle and leave their dirt marks on the brushwork of a sacred theme." Of the Butterfly Hall says (54) "In antiquity the image of the butterfly, emerging from the chrysalis stood for the soul leaving the body at death. In Christian art the butterfly is the symbol of the resurrected human soul; and in seventeenth century "Still life (291) the life cycle of the caterpillar, chrysalis and butterfly symbolizes life, death and resurrection."

8. The problems identified by Dickenson concerning the transition from drawing to print media, the conventions of cutters and engravers, the interchangeability and modification of images and plates that have been separated from original purpose.

9. Durer's *Rhinoceros* 1515, in Dickenson (61) and Gombrich *Art and Illusion* (71).

10. Jan Jonston (1603-1675) was born Poland and lived in England, the Netherlands and Germany, and published numerous books on natural history.


12. In Merian's own engraving she depicts herself as the entomologist working in the field collecting samples. Apart from her work as an artist Merian was sold colours (pigments) and prepared preserved insects, and was successful with the business of self-publishing (Davis 144-145.)

13. After the end of her marriage to Andreas Graff in 1685 Merian and her daughters were living with Labdists, a Protestant regeneration community, based at the castle of Waltha near Leeuwarden, in the province of Friesland.

14. Dickenson (150) quotes part of Catsby's qualifying introductory note for his readers on the problems of hand colouring which acknowledges the role of the image and its independent status.

   "Of the Paints, particularly Greens, used in the illumination of figures, I had principally a regard to those most resembling Nature... Yet give me leave to observe there is no degree of Green, but what some Plants are possess'd of at different times of the year, and the same Plant changes in Colour gradually with it[s] Age... What I infer from this is, that by comparing a painting with a living Plant, the difference of colour, if any, may proceed from the above-mentioned cause."

15. In his study of the relationship between the European's representation of nature and English landscape painting, Smith examines the role of analytical empirical observation as a disruptive influence to the neo-classical theory governing landscape painting that stressed unity of mood and expression. The classical order of enlightenment philosophy both connects and disrupts the typical in landscape painting with the scrutiny of nature.

16. E. H. Gombrich's "dominant purpose" in his essay *Map and Mirror: Theories of Pictorial Representation* (188) qualifies among essentials for Dickenson's study of art and science of the New World. This study exposes the historical bias for prioritizing textual analysis rather than visual, and how marginalization of visual knowledge, the separation of image and text is embedded in institutionalized structures.
Crump defines “Modern Science” as the 400-year period from mid-sixteenth century to the nearly the middle of the twentieth (1945). A period when science was influenced by the instrumentation of optics, the telescope and microscope, and when optics, science and the botany of notebooks—collecting, sorting and naming, was transformed by modern science.

A note of contradictory combinations of scale and the dual nature of naturalistic representation are made by both Martin Kemp and Gombrich in Dickenson (233).

Crump (3) qualifies this as—“the impact of light on the lens of the eye; on the other side are neural signals transmitted to the visual cortex, the part of the brain concerned with sight.”

Nabors describes Van Leeuwenoek’s lenses magnifications as being up to 500 times, though others state this as between 270 and 300 times.

For a discussion of the relationship between optical instrumentation, biological and molecular and other areas of science such as chemistry and physics, refer to Simon Schaffer’s discussion in “History of Optics”, In our time with Melvyn Bragg, BBC Radio 4 3 March 2007.

Refer to detail in Nehemiah Grew’s The Anatomy of Plants with an Idea of a Philosophical History of Plants and several other lectures Read before the Royal Society 1682, and note also development of publishing and print technology; particularly the use of copperplate engraving that supported the demand for representing this fine detail.
Chapter 3 Herbae nudae and icontype: the graphic conventions of herbals and the botanical treatise

Introduction

“...the subject has been treated by Greek writers, whom we have mentioned in their proper places; of these Crateva, Dionysius and Metrodorus adopted a most attractive method, though one which makes clear little else except the difficulty of employing it. For they painted likenesses of the plants and then wrote under them their properties. But not only are the pictures misleading when the colours are so many particularly as the aim is to copy nature, but besides this much imperfection arises from manifold hazards in the accuracy of copyists...For this reason the writers have given verbal accounts only.” Pliny the Elder’s first century AD Historia Naturalis (qtd. in Rix. 9).

Botanical knowledge and its study is the subject of a range of disciplines, activities and many different types of published material from field guides to floral pattern books. Following the overview of the developing concepts of imaging nature in Chapter 2 this chapter explores the different graphic conventions used to represent plants in printed herbals of the early modern period and the botanical treatise of the scientific Enlightenment. These publications span the era of developments in printing technology, in woodcut prints of the late fifteenth and early sixteenth century and copper engraving of the eighteenth century.

The different styles of representation of botanical subjects in printed herbals and botanical treatises reflect their respective use and purpose; changes in the relationship between images and texts; innovations of a graphic language and of ocular technologies. By comparing the status of the visual data in woodcuts and copper engravings we can understand developments in printmaking technology and the way that objects in the natural world were regarded. This discussion of the historical use of print technology and images of nature resonates with aspects of the way visual
material that originates from specialist contemporary contexts (digital imagery) is regarded and understood. The significance to this chapter’s exploration of the changing status of images lies in the implications for readings of images in the wider environment and a modern context saturated in the visualization of data.

3.1 Characteristic difference: description and analysis

“The herbal had very largely depicted the whole plant without supplementary details but in the service of various taxonomists botanical illustration shifted its focus to accommodate and explicate differing theories.” (Saunders 88)

Although botanical subject matter prevailed in both the herbal and botanical treatise, in her comprehensive analysis of the history of botanical illustration (1995), Gill Saunders (88) makes the distinction between the criteria that underpinned their contents and styles of representation. The printed herbals produced in Western Europe from the fifteenth century were selective, and their specimens were chosen for their known pharmacological value. The purpose of the herbal was to describe the whole plant, from its root to its crown, and ensure its identification for specific medicinal purposes.

As discussed in Chapter 2, because the visual accuracy of images in herbals varied greatly, the accompanying text descriptions were needed to establish the identity of a specimen. The text and illustration in the herbal was essentially a history of accumulated knowledge, of belief, myth and lore, and was based on the repetition of received wisdom.

Conversely, the botanical treatise was characterized by a culture of exploration, empiricism, observation and experience. It developed in response to vast quantities of new, unknown and unidentified plant material that required study and classification (irrespective of medicinal values), and unlike the herbal, it was inclusive. In it the image functioned as an analytic tool, expressing the theories of the taxonomist (such as Tournefort and Linnaeus).
Establishing the identities of the unknown subjects by their shared physical characteristics (Genera/Family) and their differences (Species, Varieties) was essential to systematic study and classification. Saunders (17) explains that this was central to the development of botany as a science that was distinct from medicine. This systematic ordering demanded a greater level of analytical observation than that needed in herbals and it required a standard of illustration that was able to “stand for the real thing” independent of descriptive texts.

3.2 “An uneasy relationship”: the status of the visual in printed herbals, text, image and copying practices.

The early woodcut printed herbals seem anomalous in the context of naturalism in painting and illuminations (and in the Venetian herbals) which were being made across Europe at the same time during the late fifteenth and early sixteenth century. The appearance and character of the plants in them is dominated by the printing process and wood block technology, rather than the character of the subject. Although produced by a “new” technology, the veracity of images in printed herbals was undermined by continued reliance on classical manuscript documents combined with corrupted copying practices. With the technology and its copying practices there was an inherent mistrust of the value of images as an empirical or definitive visual reference. Pliny expressed his concern about the “manifold hazards” of images and their limitations to show colour or seasonal differences. In her critical study of the pictorial tradition of “scientific illustration” from the sixteenth to nineteenth century, Victoria Dickenson refers to the image and text descriptions in herbals as having an “uneasy relationship”. Dickenson endorses the warning of the alchemist Hieronymus Braunchweig, author of The Boke of Distyllacyon, to (his) readers in 1500, that its images were “nothing more than a feast for the eyes” (Saunders 20), and the action of
Hieronymus Bock (1498-1554), who in 1533 refused to include illustrations in the first edition of his herbal *New Kreüter Buch* (Dickenson 84).

Comments by publishers and authors echoed Pliny’s skepticism about “the hazards in the accuracy of copyists”, which was based on the problems of the degeneration of manuscripts through hand copying, as in this example of the acrobatics of Meadow saxifrage in Figure 3.01.

The drawings of Meadow saxifrage Figure 3.01(a-d) illustrate the problem of copying and distortion. 3.01(a), (b), & (c), were all copied from the same source, (Blunt 56); 3.01(d), shows the illustration in a twentieth century field guide. Figure 3.01(a), resembles the original seventh century source; in 3.01(b) the copyist has literally turned the image on its head and has interpreted the granules as fruit; and in 3.01(c) the copyist has redrawn these berries as flowers.

In the *Grete Herbal*, London, of 1526 (Figure 3.02), the link between images and text is a physical one, as both were cut from the same piece of wood, creating a complete word and picture unit. Common in the second half of the fifteenth century especially for producing popular books such as the Bible, these books were referred to as ‘block’ books and between thirty and fifty sheets were bound together. The earliest of block books were printed by hand rubbers in brown or grey ink, and in black ink on a printing press as in this example of the *Grete Herbal* which would have been one of the few made after 1500 (Lambert 23). Although cutting type in this way was laborious and printing costly, the layout of the *Grete Herbal* with its blocks of text, decorative leafy capitals and “boxed” plant illustration recalls the style of an illuminated manuscript. Saunders refers to its images as “debased ciphers barely identifiable with their ostensible subjects” (21).
The blocks containing the plant images in the Grete Herbal offered a marginal amount of data for identification. The specimens were pared down to cryptic symbols that outlined simplified and generalized plant shapes. Characterized by minimal linear detail without shading, perspective or texture the visual here neglects to show the features, such as scale or seasonal variation, that would aid identification. The images in Figure 3.02 show “the betony(?), date palm and endive” which Saunders (21) describes as having “little resemblance to the subjects”. While the inclusion of these images appears to serve the purpose of breaking up the visual density of blocks of text, Dickenson (56) suggests that an absence of finer line detail, owes more to the costs of cutting plates and the limitations of the inking process which was done using leather balls soaked in ink (which were precursors to rollers), than it does to inability of draftsmanship.

In addition to the cost and difficulty of inking the woodcuts, cutting with a knife and chisel to replicate the qualities of a fine pen drawing or the feeling of a watercolour, is problematic. Even when a skillful cutter (formshneider), in a secular context often a member of a carpentry guild, is guided by an artist’s drawing on the plate and sympathetically interprets a detailed drawing, close finely cut lines on a block are difficult to ink and to print consistently without blotting the ink. (Also affecting the print as a consistently reproduced copy is the variation in paper quality, which is made smoother (“good”) on one side than on the other, and so contributes to the print’s consistent appearance.)

Where moveable type was used and the images and texts were made separately, the process was (still) a collaboration between an artist, a form cutter and printer. This also allowed for discrepancies to be magnified or modified at any later stage. Saunders (22) describes ways that naturalism and accuracy of original source documents was lost when old printing blocks were sold, reused, modified and changed without reference to the objects they represented, or the same woodcut was sometimes used to illustrate.
different plants described in the text. Dickenson (83) suggests that these copying practices indicate that the potential of the new printing medium for consistently and accurately multiplying an image had not been realized.

The composition and the imprint of the wood block dominate images of plants in early herbals giving them a rigid formulaic appearance. The character of the woodcut imposes itself on the plant subject and the composition is characterized by symmetry and a formulaic spatial flatness which is reinforced by the generalized form of leaf shapes and minimal linear detail. The symmetry of designs accentuates what Saunders (31) refers to as “rectangularization”, where the plant is squashed into the small wood block. This practice is evident in the two examples of Mattioli’s Solomon’s seal and Viola purpurea (Figure 3.03 & 3.04). In the latter it also has the effect of confusing the perspective where the leaves and roots overlap; in addition to this the artist or cutter neglected to show the detail of how the petals of this plant characteristically overlap.

Subjects often featured fanciful anthropomorphic additions such as the Mandrake’s forked root in male and female form Figure 3.05(a-c). The examples in Figure 3.05(b) are both from _Ortus Sanitatis_ of 1497 (above) and reprinted 1511(below). The visual simplicity and economy of line referred to in the previous example is evident here, and although the cryptic cartoon like quality is not a visually true representation, it would have still been useful for identifying a plant with such a distinctive root structure.

_Ortus Sanitatis_ Figure 3.05(b) is one of the parent documents of the French work _Le Grand Herbier_ Figure 3.05(c). This example also showed the mandrake, and its “boxed” images, symmetry and “rectangularization” resemble closely the English version of the _Grete Herbal_ (Figure 3.02) discussed earlier. The naturalistic eighteenth century engraving Figure 3.05(a) showed the extended legacy of the anthropomorphic
mandrake in herbals and coexistence of this style alongside the empirical visual material usually associated with this period.

3.2.1 Colour in woodcuts

Despite the limited palette of pigments available to the artists of the sixteenth and seventeenth centuries, Blunt and Stearn (58) comment that most herbals were intended to be hand coloured images; a few would have been coloured by the artist so that they could be referenced for the colour calibration by the printer and assistants (possibly children), and others would have sold at lower prices for the owner to colour, or leave as black and white.

The limitations of early woodcuts for showing detail and the discrepancies of copy even where the image has been given greater attention can be seen in the Chamomile and the Peony (Figures 3.06 & 3.07) from Ortus Sanitatis, Strasbourg, c. 1500. Even when Saunders (19) compares them to their source document the German Herbarius (1485) and finds they are not accurate reinterpretations, they are less generalized simplified references than the images in Grete Herbal, London, (1526).

The lines of these woodcuts were consistently mechanical and this contributed to a stiff wooden appearance especially where the subject had soft or fine feathery leaves, as in the Figure 3.06, Chamomile (Chamaemelum nobile) Ortus Sanitatis, Strasbourg, c. 1500. The overall linear quality varied little whatever the features of the subject and it lacked the level of detail produced in the later woodcuts of Hans Weiditz (d. c1536) and Albrecht Meyer. In the absence of convincing perspective and with repetitive flattened leaf shapes and heavy even line quality, the plant feels as if it has been pressed into the surface of the plate (it almost resembles a dried herbarium specimen, and recalls the illustration of some dried specimens in Dioscorides’ Codex Vindobonensis). The curly tip of its leaves have uniformity and the appearance of being
assembled from a pre-set template pattern, rather than something that grows organically.

Similarly, the image of the Peony (Paeonia mascula) Figure 3.07 was dominated by the qualities of woodcut’s uniformity of line rather than the softness and character of the subject. Noting the inconsistencies of the inaccurate copy, Saunders (19) compares this print with its source document in German Herbarius (1485), and observes the way its tight buds are shown here tapering to the shape of a rose bud as well as the exaggerated formulaic shape of the roots.

The status of the visual in printed herbals remained subordinate to text until the radical graphic innovations and refinements in the woodcuts of Hans Weiditz (d.c 1536) and Albrecht Meyer. Their plant subjects transcended the stiff formulaic style and the heavy imprint of the early herbal woodcut, and they showed portraits of living plants.
3.3 Specific and general plant portraits: the real time observations in Brunfels’ *Herbarum Vivae Eicones* (1530-36) and Fuchs’ *De Historia Stirpium* (1542).

The development of the graphic conventions by the artists Hans Weiditz (d. ca 1536) in Otto Blumfels’ *Herbarum Vivae Eicones*, Strassburg, (1530), and Albrecht Meyer in Leonhard Fuchs’ (1501-1566) *De Historia Stirpium*, Basel, (1542), gave the representation of botanical subjects a new status. Their drawings and prints were from life rather than copies of earlier images and this gave them a visual accuracy and value for identification that did not rely on textual verification. Weiditz and Meyer’s graphic innovations were a radical departure from the images in the earlier books.

Weiditz was a student and nephew of Durer and his illustrations were published in the *Herbarum Vivae Eicones* (1530-36) compiled by Otto Brunfels. The text was based on Classical and medieval sources but illustrations were derived from his own observation and were considered a landmark “in the development of botany as an empirical science” (Saunders 20). The title alone ‘living portraits of plants’ was an indication of its departure from earlier practice of copying from existing documents.

Weiditz’ watercolour of a Comfrey Figure 3.08 retained a naturalistic quality even when transferred to the woodcut in Figure 3.09. In both of these images Weiditz produced a “warts and all” portrait of a specific botanical subject. He included detailed features of blemishes, insect damage and showed wilting of the specific sample. In order to fit the whole plant into the design Weiditz used two solutions: in the watercolour (Figure 3.08) the root and stem were drawn in sections and in the print (Figure 3.09) the stem was folded and drawn in that condition. The drawing itself did not distort; instead, it was visually faithful to the condition of the folded stem. Weiditz’ drawing in the print transcended the lifeless intractability of the hard-edge woodcut line (described earlier
in relation to the Chamomile) and it approached the subtlety of watercolour line, and these specimens had a delicate naturalistic quality. Using perspective, the leaves were varied and particular, and by showing them from all angles, side, top and bottom, they were convincingly three dimensional and present.

3.3.1 An early type specimen

The Pasque flower Figure 3.10 was similarly observed and represented by Weiditz: its fine hairy (sometimes) wilting stems and irregular open design showed particular detail of the actual plant. Though fading, its vigorous and energetic growth was evident, and by drawing the spaces within the plant’s stem structure – Weiditz’ gave it a convincing three dimensional and physical presence that contrasted with the pressed flattened appearance of specimens in earlier and other contemporary sixteenth century herbals.

The Pasque flower’s inclusion in Vive Econes is now considered one of the most significant in the history of botanical illustration (Saunders 25). In addition to its fresh naturalistic quality, it was a subject not generally included in herbals because, in the absence of any reference to it in Classical texts, it was designated herbae nude. Weiditz interest in an apparently (medicinally) useless and anonymous botanical subject extended the conventions dictated by the selective herbal tradition. Despite criticisms of Weiditz that his plant portraits were too specific to be ideal type specimens, this is one of two type pictures of a Linnean species.

A “type” specimen is the original specimen used to describe and establish a species name and identity and it is usually preserved in a herbarium. In cases where the type specimen is lost, the “icotype” a (type) drawing, or even a print, may replace the type specimen (Saunders 97).
3.3.2 Taking peculiar care Leonard Fuchs (1501-1566) & De Historia Stirpium (1542)

The second herbal of great significance for its accomplished woodcuts, influential visual innovations and its correlation of images with text was Leonard Fuchs’ *De Historia Stirpium* (1542). In the Crocus (Figure 3.11) Fuchs’ artist Albrecht Meyer included two versions of the plant to depict successive seasonal change in its life cycle. Beside the flowering Crocus was the same plant with its foliage fully developed, and both specimens showed the changes to the bulb. This practice was also applied to a singular specimen and in some prints the flower and fruit appeared simultaneously. Although this offered “a complete account of the botanical facts” (Saunders 27) it was also confusing, and was subsequently replaced by showing the parts separately. This example of Meyer’s work also showed his use of life-size scale, and this visual fact enabled greater independence from textual description.

In Figure 3.12 fine line work is consistent over the Butterbur image and there is clarity and detail in each part of the drawing. The plant has been spread out clarifying its form, and in this diagonal position it also accommodated the extensive root, — an alternative to Weiditz’ device of the bent or separated stem seen in Figures 3.8 & 3.09. These fine lines and the absence of shading resolve the visual spatial ambiguities of the overlapping leaves, and gave a flat diagrammatic feeling to this and other examples of Meyer’s plants. Saunders (26) explains that these prints were intended to be hand coloured and colour copies of this print correspond with the colour described in its accompanying text and clarify the perspective. In a method that echoes Weiditz’ simultaneous representation of the seasonal variation of the Crocus, Meyer showed together two different coloured flowers such as the blue and white of a “wegwort” (chicory), on the image of the same specimen.
The graphic innovations of Fuchs, such as his inclusion of variable seasonal features within one image, life-size scale, and the correlation between graphic and textual information, were accompanied by his use of the ‘page-plate’. In *Historia Stirpium* 1542 the text was excluded and the page was devoted entirely to the image. The importance of the image to Fuchs is reflected in his meticulous supervision of the entire process of translating the drawing to print, and the impact of this innovation was shown by the fact that his woodcuts were still being used well into the seventeenth century. He clearly expressed his expectations of the image and its intention refer 1.6

The differences between Weiditz and Meyer (respectively in Brunfels and Fuchs) are summarized by Saunders as the difference between a specific and general interpretation. Weiditz gave an individualized portrait of the plant; he included its flaws and was true to the wilting leaves, whereas Meyer smoothed over imperfections and his specimens were perfectly intact in a robust and generalized account. Despite these differences, Weiditz and Meyer in their practice of direct observation and reference to the (fading or robust) specimen, were essentially complimentary. The standard of their work was influential for subsequent authors and publishers, and their graphic innovations survive in conventions of contemporary illustration. Saunders (36) credits Fuchs’ oeuvre as “the beginning of a new emancipation of the image, and its establishment as a primary source for botanical data.”
3.4 Inclusion and connection “herbae nudae” and “licotypes”: The partnerships of Georg Dionysius Ehret and Carl Linnaeus, Ferdinand Bauer and Robert Brown.

“...every Botanist will agree when he has examined the plates with attention, that it would have been a useless task to have compiled, and a superfluous expense to have printed, any kind of explanation concerning them; each figure is intended to answer itself every question a Botanist can wish to ask respecting the structure of the plant it represents” Joseph Banks 1796 (qtd. in Dickenson. 180).

Between the production of the sixteenth century herbals discussed above and the images in the botanical treatise of the eighteenth century there were major cultural social changes in Europe, and with these changes were the innovations and developments of observation and print technologies. Microscopy and engraving combined and assisted in the task and scope of descriptive (and pharmacological) botany which was challenged by the amount of botanical material that was made available by the voyages of discovery to America and the Pacific. According to Dickenson (147) “everything changes” regarding works of natural history, with the publication in Amsterdam in 1705 of the 60 full-page colour engravings in *Metamorphosis Insectorum Surinamensium*. Saunders (65) notes how the status of the drawing was enhanced by its use in conjunction with dried specimens which enabled a visual record to transcend climatic disparities long enough for specimens to be observed and classified.

The received wisdom and knowledge that formed the basis of the herbal contrasted with assimilation of the unknown and new in the Botanical treatise. This task was based on observation of the physical subject itself. The visual documentation of structural botanical attributes was the most reliable basis for classification compared to arbitrary, superficial or variable features such as their use, colour or size. (See footnote 5 regarding the methods of arranging and ordering the information in herbals and footnote 3 on...
the naming of specimens.) The Botanical treatises discussed in this chapter reflect the
growing understanding of the value of accurate imaging as new knowledge.

In the absence of supportive authoritative texts the images of new and unfamiliar
subjects required a higher standard of illustration than had been necessary in herbals,
with their reliance on received wisdom. There was also a greater need for images to
support the increasing level of interest and correspondence about botanical subjects
between collectors, gardeners, horticulturists and botanists, which demanded
exchange of comparable visual data. Linnaeus in the Hortus (1737) stresses the need for
illustrations to be the natural size and notes the skills of manipulation required by artists
representing a six-foot plant (Dickenson 175).

The difference between the descriptive herbal of Fuchs’ (and Meyer’s) portraits of
whole botanical subjects, and Georg Dionysus Ehret’s (1708-70) work in the botanical
treatise, reflected the fundamental shift in the attitude to the visual and the way nature
was regarded. Summarizing this difference, Saunders (89) explains how “increasingly
illustration was fundamental to the development of botanical science; there could be
no substitute for a picture in conveying quickly and unambiguously theories of
classification that were founded on the physical character of plants.”

In two examples of copper engraving (Figure 3.13 and 3.14) Ehret presented with a
structural analysis of the botanical subject, a visual description that expressed Charles
Linnaeus’ (1707-1778) theory of plant classification. Many of Ehret’s works exist with
specific reference to dried species and herbarium notes and in the context of
specialized readings.

Linnaeus method was based on the structures of the flower and fruit, and he
emphasized enumeration of the ratios in a flower of the stamens and carpels to
characterize and construct artificial groups. Ehret worked closely with Linnaeus and undertook floral dissections to illustrate the 24 principal classes of the sexual system shown in the table in Figure 3.13 that was published in his Systemae Naturae (1736) as well as in Genera Plantarum (1737). The illustrations were used to popularize and disseminate Linnaeus’ system of classification.

In Ehret’s engraving (Figure 3.13) the parts were laid out in (on) an easily identifiable table where visual description and comparison took precedence over the text. It presented 24 principal classes of the Linnean sexual system and a coloured copperplate engraving facilitates a level of fine line detail that surpassed the woodcuts of Fuchs and Weiditz. Similarly fine detail is evident in Figure 3.14 which presents a dissection of the reproductive parts of the fig and this is clearly laid out across the surface of the entire plate as though we are looking into a box or container. Colour has been applied to all segments except the most microscopic areas. This plate illustrated only the physical characteristics important for this method of classification and excluded all other features. These tables were diagrammatic constructions of new botanical knowledge and while some explanatory figures and text were included, it was located on the lower edge of the plate and supplemented the very centralized visual information. This layout contrasted strongly with the relative status of the image to text in the block book page from the Grete Herbal, where images functioned as a device to visually break up dense columns of text.

Paradoxically, while the premise of the botanical treatise was inclusive in its attempt to embrace and connect vast quantities of new botanical material, individual drawings and prints (by Ehret and others) showing “the particular”, also presented a reduction in the overall amount of information about the subject. By including only information pertaining to the specific theory, an individual specimen was contextualized in its relation to others sharing those characteristic types of features. Because the Linnean
system is based on the morphology of flowering parts of the plant, many representations resemble the precision of flower painting rather than botanical art; and numerous artists such as Redouté worked in both areas. As Saunders explains, the absence of plant parts considered irrelevant to the Linnean theory of classification, is reminiscent of herbals that neglected to show “the root (if) it was of no significance characteristically or economically” (32)

Another example of a table that uses Linnean criteria is Johann Gesner’s Triandria (1795-1804) Figure 3.15. “Triandrian” plants are those with three stamens. In this tightly packed table, Gesner brought together the crocus, lily, gladiolus etc. and others, in one colour plate. The space was divided into twelve distinct frames separating each example and boxing-in each specimen with its own flower, seeds, bulb, and foliage.

In a style different from these tables is Ehret’s watercolour and bodycolour on vellum of the American Turk’s-cap lily (Lilium supebum) (Figure 3.16). A copperplate version was published in Trew’s Plantae Selectae (1750-53). The proportion of the plant that Ehret showed here was the flower-spike, and by taking “centre stage” it had a strong resemblance to flower painting. The graphic conventions Ehret used in this image resembled Maria Sibylla Merian’s presentation of plant subjects that I discussed in Chapter 2. Refer for example to Figure 2.06: the bold vibrant colour, the central position of the plant subject within a decontextualized space, the three-dimensional form of the plant structure, and high level of visual accuracy characteristic of the compositions in Metamorphosis (1705). Ehret presented the visual facts of buds and blooming flowers painted from all angles with such a high degree of realism that the ratio of stamen and pistils can be easily assessed, and this was crucial to locating it within Linnaeus system. Ehret’s textual description is positioned (relegated to?) lower right and left of the central stem and did not visually interfere with the drawing. It included information of the location and the dates it was observed with a descriptive Latin name; in this
example the simpler binomial system that was the lasting legacy of Linnaeus' work has not been used.16

Although as described above, Ehret's concentration on the flower was similar to the appearance of plant images in floreliga and flower painting, the white background space served to decontextualize the subject. This was and is generally a standard spatial convention in botanical illustration where the isolated subject, as a specimen can be recognized and understood immediately. (The botanical subjects drawn in the sixth century manuscript of Dioscorides' Codex Vindobonensis were the central feature of the space in its pages, its ancient text is arranged around the “freely” positioned specimen.) In Art and Illusion. (193) Gombrich refers to the relationship between recognizing this particular set of spatial conventions and understanding the value of the image as “the conditions of illusion”, (and this is discussed in relation to Maria Sibylla Merian's work in Chapter 2, A Metamorphosis). Apart from field guides which accurately depict plants in a specific environment, other methods17 that showed the specimen in relation to plants and their habitat were generally considered unscientific: that is, representations that did not conform to a certain set of pictorial conventions and codes, such as Linnaeus' did not contribute to new botanical knowledge (Saunders 92).

The implications of establishing standardized modes for depicting plant subjects contributed to the systematic development of a significant body of botanical knowledge, and in cultures colonized by Europeans in the eighteenth and nineteenth centuries, it required these artists to be “trained to satisfy the aesthetic and cultural standards of Western botanical art”. Saunders has summarized the adjustments that Indian18, Japanese and Chinese artists of botanical subjects respectively were required to make to their traditional styles in order to comply with the demands of (European) “scientific botanical draughtsmanship” in the nineteenth century. With regard to Indian
artists trained in “the methods and styles of Mughal miniatures,...the solid gouache, the formality and symmetry, lack of modelling and perspective, were replaced by Western practices: the use of flexible European paper, the exact copying of the plant in pencil or sepia ink, with subtly modulated washes of watercolour, using European illustrated books as models” (80). This is significant for appreciating the way in which,

“[by] imposing Western pictorial conventions such as perspective, the West colonized native perceptions of the flora, and effectively devalued ‘other’ ways of seeing and representing what was seen. The European style of illustration was eventually adopted everywhere, even in China and Japan where it supplanted the decorative though naturalistic imagery that had predominated in botanical books for centuries. It is in consequence of this that there is now a set of standard conventions, a universal graphic language for botanical illustration.” (81)

Keith West’s conclusive book How to Draw Plants: the techniques of botanical illustration first published in 1983, acknowledges (60) “the stipulations” of (correct practice) by Walter Hood Fitch (1817-92) who is recognized as the most prolific of all botanical artists. Fitch’s eight articles in The Gardener’s Chronicle (1869) are regarded by the scholarly authors of The Art of Botanical Illustration, Wilfred Blunt and William T. Steam (261), to be “valuable notes on the technique of botanical drawing”. In addition to the correct selection of materials, Fitch’s articles offered “rules” and guidance on colour, shading, perspective and magnification;
analysis of different structures including stems, flowers (orchid) leaves, and leaves in perspective.

Saunders (100) explains that in treatises of taxonomy after 1750 it was typical to neglect details such as bulbs, seeds, or roots that were either irrelevant in the classification system, or were without economic significance. Conversely, current practice is for illustrators to include the whole plant and its underground parts, as in Figure 3.17 Dog Violet (viola canina) from Stella Ross-Craig’s (1906-2006) Vol IV of Drawings of British Plants, 1948-73.

Similarly to Ehret, Ferdinand Bauer’s works in Sibthorp’s Flora Graeca London (1806-40) and his own Illustrationes Flora Nova Hollandiae, London, (1813-16) resulted from collaborations and expeditions with two botanists John Sibthorp (1758-1796) and Robert Brown (1773-1858); Bauer and Sibthorp traveled to the Eastern Mediterranean (1786). Bauer’s work was characterized by extensive use of microscopic detail and according to Hewson (51) he used a device known as a camera lucida. His approach refers to a different system of classification that reflected the influence and collaboration with botanist/naturalist Robert Brown. Bauer’s work followed the system of classification used by Robert Brown—the ‘natural’ system of classification devised by Laurent de Jessieu, which included a greater range of information and microscopic visual data (and of flora and fauna), than in the images that resulted from Ehret’s partnership or collaboration with Linnaeus (Hewson 51).

While Ehret’s American Turk’s-cap lily (Lilium supebum) Figure 3.16 was observed growing in the garden of the collector Peter Collinson, Bauer’s preliminary observations of his subject were undertaken on the expedition to Australia (1801-1805) led by Mathew Flinders. His observations were recorded in a series of pencil drawings (now in the Natural History Museum Vienna) with codified details about the colour, and were
later worked up into extensive and life-like full colour paintings. Bauer’s colour codes extended to 1000 colour references, and his use of colour and tone support the drawing of the perspective and reinforce its illusion of three dimensions. When Goethe said of Bauer’s images in *Digitalium monographia* 1821 by John Lindley, “Nature is visible Art is concealed”, not only did he reflect a European idea that Western botanical illustration had a “truth to nature”, he referred to the way Bauer depicted a specimen in its “true spatial relationship” (Saunders 14).

As Bauer’s work illustrated and Dickenson (57) states, “Colour is not trivial in natural history”. The problems of the stability and permanence of color pigments inaccurate colour reproduction had been mentioned by Pliny, Fuchs, Merian and others, and this continues to be a problematic issue for traditional and digital print technology in the twenty-first century. The discrepancies between the properties of watercolour paint and printing ink, point to what Dickenson (242) describes as “the complex interrelationship between the technology of printing and the nature of representation”. In addition to the different behaviors (properties) of pigments in paint or in ink,—the technical conventions of the woodcut and the engraving require a tactile hard edge to be equated with the artistic conventions offered by the properties of watercolour, with its soft lines blending the colour and tone.

Bauer published the paintings himself as colour copperplate engravings and apart from the title page, preface and legends, the images were without text in *Illustrationes Florae Novae Hollandie*, (1813-16). As the subtitle of Figure 3.18 indicates (“Brown prod. fl. nov. holl. p. 379. 29”), each plant had a corresponding textual description in *Prodromus Florae Novae Hollandiae et Insulae van-Diemen* (1810) volume 1 that was published by Robert Brown. The books were complimentary; text and image no longer compete for the space of the page. Brown’s alternative method of classification (to Linneaus’) was based on Antoine de Jussieús *Genera Plantarum* (1789), a “natural”
system that divided plants into Monocotyledons and Dicotyledons, and with its use of the plant’s embryology as its basis, it demanded microscopic definition from Bauer.

In Figure 3.18, the features of the Grevillia Banksii were represented in complete and minute detail. Central to the image was the flowering stem showing different stages of the process. Bauer’s draftsmanship and his use of light and dark tone created the convincing illusion of three dimensions and the clarity of the illustration continued with the full microscopic dissection magnified, and arranged in the lower section on each side of the stem. As a reference to scale Bauer generally included one structure in the illustration at its naturally occurring size (Hewson 50).

Similarly to Fuchs, Bauer controlled the process from start to finish. He drew and engraved his own plates and he hand coloured the original sets of prints himself. Hewson (45) describes his engraving technique as “a combination of line and stipple with apparent touch of mezzotint on the stipple”. In analyzing Bauer’s plate, the elements of illusionist pictorial space within the flowering stem occurred within a recognizable schema of the decontextualized white space of the botanical treatise and its graphic language.

This chapter has concentrated on examples that show the construction, acceptance and understanding of particular pictorial codes (of decontextualized space, scale or structural fragmentation) and their relationship to the purpose of the image. The value and use of either a particular graphic language or generic representations, in illusionist pictorial representations (usually coloured) or the outlined schematic images, were relative to their respective purposes of identification and analysis. While these examples illustrate the purpose and development of graphic conventions, and indicate the relationship between representing botanical subjects and graphic technology, they show the shift from Pliny’s distrust of botanical images to a position where the herbae
nudae were given the status of the icotype. Joseph Banks in the late eighteenth century could have confidence in the visual as essential to the progress of scientific knowledge.

### 3.5 Plant chemistry and taxonomy

Eighteenth century Linnean plant taxonomy in which observation and visual assessment of a (plant) specimen’s structure and appearance governed its identification (and systems of classification), was criticized at that time, as being unreliable and “artificial” for being too selective Saunders quotes Michael Adanson Familles de Plantes (1763-4) “The botanical classification which only considers one part or a small number of parts of the plant are arbitrary, hypothetical, abstract and cannot be natural ... the natural method in Botany can only be attained by consideration of the collection of all the plant structures” (97). Saunders summarizes a number of “natural systems” that were developed in the nineteenth century, including French botanist Laurent de Jussieu (1748-1836) and German writer Johann Wolfgang von Goethe (1749-1832) and the Swiss botanist A.P. de Candolle (1778-1841). Highlighting the work of the influential English author of Botanical Register John Lindley (899-1865) who followed de Candolle’s theories, and the Scottish illustrator of Botanical Magazine in the late 1840s, Walter Hood Fitch, Saunders notes the latter’s distinction between a plant illustrated with “ornamental intent” and “[the same plant] of more scientific character... accessorized with details and cross-sections”.

In the twenty first century, classification of biological phenomenon is complex, and taxonomy remains an important branch of modern biology. However, taxonomic problems can now be solved using a range of techniques including DNA and Protein sequence analysis. For example, the significance of chemistry in taxonomy is illustrated by Southam’s example of a fifty year old “argument” over the identity of two liverworts
(Hymenophyton leptopodum & Hymenophyton flabellatum)-and whether they were two different species.

“During the 1970s, organic extracts of a group of compounds called flavonoids from both liverworts were examined by paper chromatography. H. leptopodum was found to contain thirteen flavonids, and H. flabellatum contained eight, of these seven were common to both liverworts. This experiment supported the view that the two are in fact different and helped to end the 50-year old argument.” (7)

Analysis of compounds allowed for evolutionary relationships among plant (and animal) groups to be studied. As recently as 2000 in the preface to The Liverwort flora of Antarctica, Bednarek-Ochyra stated that, “Plant taxonomy is in a new era in which DNA sequencing and other molecular techniques will almost certainly revolutionize biological systematics.”

Having charted here the development of the universally graphic language of the botanical the treatise, in the following chapter I examine early nineteenth century illustrations of very small plant specimens and their cell structures that stretched the limits of optical technology, and discuss their purpose, value and role in the development of new knowledge. The significance of the twentieth and twenty first century cell images, and methods of visualization of specimens at a sub-cellular and molecular level will be discussed in chapter 5.
These are just two, and apart from the herball and botanical treatises discussed in the essay, others include botanical monographs (works devoted to a single family of plants); florilegia, (decorative flower books often associated with a particular garden), and horticultural literature.

Plants that were unknown to the Classical texts that these works were based on were referred to (by Weiditz and Fuchs) as herbae nudae: they were described as “bare” because their absence from Classical texts meant that they were unnamed.

These texts served the eclectic, complex, confusing nomenclature described by Lys de Brays (20) as a chaotic combination “of Latin, Greek, latinized Greek, Arabic, latinized Arabic, French, latinized French, German, latinized, German, anglicized Latin anglicized French, many common names and the same name doing duty for several quite different plants.”

Animal and plant material previously unknown to Europeans which was brought from the voyages of discovery in the new and other New World. The ‘Columbus letter’, a broadsheet first published in Barcelona 1493, was translated and republished in Latin and Italian with illustrations describing the unfamiliar landscape of America. Over five years and in seventeen editions, his accounts of what he had seen spread though out Europe. (Dickenson 20)

Plants in herballs were arranged mainly according to medicinal properties although as Saunders (24) describes this and other methods were based on superficial rather than “systematic similarities. Different principles are often combined in the same book and around things such as taste, smell, edibility or around parts of the body they were used to treat; or alphabetically and by combinations of Latin, Greek and German indices; or by ‘apothecaries’ and herbalists’ names”; or by type or habitat.

By the late 16th century in Europe when chemical remedies were developing.

As well as this, contemporary European painting including well known watercolours by Durer and studies by Leonardo da Vinci, also contrast with the naturalism of Classical images of plants reproduced in the 6th century Codex Vindobonensis.

The lineage of the Græte Herbal. London, 1526 illustrates the way texts were reinterpreted the source material corrupted, it was an English version of the French work le Grant Herbier c.1486-88. The images in it were drawn from this and other sources including Jacob Meydenbach’s Ortu Sanitatis, Mainz, 1491 and two thirds of its illustrations are based on the Peter Schöffer’s German Herbarius 1485. The Peony in Ortu Sanitatis (c.1500) Figure 3.07 was based on the German Herbarius (1485).

The status of images was noted by Pliny the Elder and referred specifically to paintings by Cratevas and other Hellenistic botanists.

Because of indentations this caused, only on one side of the paper was used, see Meggs (61)

An influential source document for them was Dioscorides’ De Materia Medica. This Classical treatise with its drawings attributed to Cratevas (spelling variations include. Krateus) survives only as the 6th century manuscript copy Codex Vindobonensis.

Dickenson (82) discusses several explanations of these images, among them Ford who said that the use of unnatural icons was an attempt to preserve arcane knowledge; Boas that in the absence of the subject to refer to the image is illustrating the text “not nature”; and Eisenstein idea that the a cryptic cartoon like image served as an aide-mémoire within “an oral and manuscript tradition” and alternately, that there was an inherent skepticism about the veracity of images dating back to Pliny’s comments about Greek botanists.

Used in Johnson’s 1636 Gerard’s herbal and in Flemish Herbal of Robert Dodoen 1517-1585. Dodoen is one of three great Dutch Flemish botanists of the second half of sixteenth century the others were Carolus Clasius 1526-1609 and Mathias Loblius 1538-1616).

Maria Sibylla Merian’s influential Metamorphosis Insectorum Surinamensium (1705) resulted from two years in Suriname 1699-1701;) Ferdinand Bauer’s work (with Sibthorp) in Greece and Asia Minor in 1780 resulted in Flora Graeca (1806-40), and the Matthew Flinders voyage to Australia 1801-1805, in Illustrationes Florae Novae Hollandiae (1813-16) here working with Robert Brown. These are two artists whose works bridge this period of assimilation of flora and fauna into a European experience and botany as a systematic science.

Saunders (89) quotes Linnaeus in his Philosophia Botanica “the essence of the flower rests in the anther and stigma .... [and the essence] of the plant in the fruitication”.

The artificial system of classification developed by Linnaeus was used by Robert Brown in Australia 1801-05 but on his return to England he adopted the alternative natural system he had studied in Antione de Jessieu’s Genera Plantarum (1798).
Thomson’s *Temple of Flora* (1799-1807) presents each plant in its habitat using 19th landscape painting conventions, and photographic gardening books generally show plants in relation to others in specific settings.


Such as Stella Ross-Craig (b.1906) Figure 3.17.

Hewson (51).

The topic of “Nature - cultures and codes of pictorial representation”- will be discussed in another part of this dissertation, such as Mark Catesby’s (1628-1749) flatness opposed to painterly methods, “Flat, ‘tho exact” an alternative to Maria Sybilla Merian, and Goethe’s description of flat pattern which he refers to as the “Chinese” style meaning illustrations of botanical subjects of other cultures such as Japan or China.
Chapter 4 Foreign Musci: botany, chemistry and biology

“All science is either physics or stamp-collecting”
Ernest Rutherford (1871-1937) in Crump xvi

Introduction

In the (new) world of natural history scholarship described so far in this thesis, “science”, was thought of by researchers such as Linnaeus as “natural philosophy”, while optics and mathematics “were recognized as autonomous” (Crump xvi). Classification that characterised natural history and the earth sciences in the seventeenth and eighteenth centuries radically changed, particularly through the development of optical instruments, and different fields of science developed because of these new technologies in the nineteenth and twentieth centuries.

Following on from Chapter 3 this chapter first considers the relationship between images, texts, and material specimens in nineteenth century botany from the Herbarium of the Royal Botanic Garden, Edinburgh. It considers the methods of representation and graphic conventions used and how the (analogue) tradition of botanical graphic language accommodated developments in optics (microscopy). This discussion provides a background for understanding the value and purpose of images, the different graphic language used in contemporary twenty-first century visualizations of dynamic processes that occur beyond the visual spectrum and are invisible to the naked eye, effecting the shifting value of visual images as core knowledge in science. The discussion begins with botany and its concern with structural features of taxonomy and in chapter 5 moves to biology and microbiology. (At molecular and “ultra-microscopic” resolutions the identity of images as plant subjects is not immediately obvious. Chapter 5 explores the value and veracity of images, as well as the empirical and aesthetic concerns of artist-scientists and the paradoxical legacy of microscopy that contributed to the mistrust of visual experience. In the twenty-first century digital tools available to artists and scientists compound the veracity of images and present a radically new graphic language.)
The concern of this study so far has been with the development of a range of images that resulted from the study of natural history, with its task of documenting, classifying and comparing new structures and forms, and using visualizations to represent plant subjects and theories of classification. This chapter considers the implications of optical technology on the changing nature of science in the early nineteenth century and the subsequent shift in the value and purpose of visual material and its contribution to the development of new knowledge. I shall argue that the continued significance and ambiguity of visualization in science corresponds with the dematerialization of the visual in contemporary art practice of installation discussed elsewhere.

4.1 Eighteenth century microscopes

Eighteenth century microscopes were structurally stronger than those of the sixteenth and seventeenth, and although by mid-eighteenth century John Cuff had developed an advanced focus mechanism that made the instruments easier to use (Davidson), what could actually be seen through instruments, used by Ehret and Linnaeus in the eighteenth century, was characterised by blurred images and optical aberration. Biologist and author Neil Campbell explains, “Two important values of microscopy are magnification and resolving power, or resolution. Magnification is how much larger the object appears compared to its real size. Resolving power is a measure of the clarity of the image; it is the minimum distance two points can be separated and still be distinguished as two separate points. For example, what appears to the unaided eye as one star in the sky may be resolved as twin stars with a telescope”(111).

The minute details shown in Ehret’s images of dissection Fruitification of the fig, and Ferdinand Bauer’s Grevillea Banksii discussed earlier (figures 3.14 and 3.18) describe the surface appearance and form, and the cross-sections show internal structure of numerous parts of the plants under magnification. As discussed in the previous chapter...
these plant subjects conformed to the conventions of a universal graphic language – (volume, form, texture, decontextualized space, etc), and the unfamiliar appearance of cross-sections could still be related visually to larger more familiar forms. These magnified and microscopic details were coherent and able to be read immediately within the context of the whole plant subject. Although illustrating the structure for the purpose of the respective botanical treatises (Linnaeus and Brown) and although very small parts were almost unrecognizable, they could be perceived as plant subjects.

4.2 Coherence: images, texts and specimens in the herbarium:

"... the shape and arrangement of individual cells in moss leaves are also important in moss identification" Conrad (2).

The selection of the herbarium specimens discussed in this chapter relate to the opportunity I had to research the images and visualizations of Antarctic vegetation through the work of Associate Professor, Sharon Robinson, School of Biological Science, University of Wollongong 4. The vegetation of this extreme environment is limited mostly to mosses, lichens, liverworts and fungi, and it is believed to be an indicator of climate change. After visiting the sub-Antarctic Plant House and research facilities in the Hobart Royal Botanic Gardens in 2003, and prior to visiting the Antarctic Peninsular (as artist in residence on the cruise ship MV Orlova January-February 2004), I began research of sub-Antarctic moss specimens and related images and texts held in the collection of the Herbarium, and the Special Collection Library and Archives, Royal Botanic Garden Edinburgh.

The identification of very small specimens such as moss is nearly impossible without the use of optical technology. Jim Conrad’s field guide Backyard Nature 2006 advises that miniscule plant specimens such as mosses “nearly always need a hand lens, and very often a microscope (to be identified)” (2). The photographic portrait of Dr. Robert Kaye
Greville (1794-1866) in Figure 4.01 shows the Scottish doctor, (a cryptogamic botanist, artist and social reformer), seated alongside a table holding a compound light microscope: as scientist, artist and illustrator this instrument was central to the purpose of his taxonomic work.

This section discusses specimen sheets from the Herbarium of Dr. R K Greville now in the Herbarium Royal Botanic Garden, Edinburgh, and Walter Fitch’s plates in J.D. Hooker’s *Flora Antarctica* (1844). It examines how the graphic conventions of botanical images accommodated the extreme variation of scale introduced by the representation of magnification of the microscopic parts of very small plant subjects. Recalling Hooke’s 1644 images of the cork in Figure 2.11, showing bark cells under magnification together with a drawn branch at natural scale, the engraving simultaneously presented the viewer with extremely different representations of the same subject. In the contexts of the specimen sheet and book plate, the representation of cell structure along side the complete plant form showed a greater leap of scale and comprehension, from invisible forms to visible, than the variations in scale that had coexisted in Ehret’s dissection of the common fig (1750-92) Figure 3.14 and Bauer’s *Grevillea Banksii* (1813-16) Figure 3.18 discussed earlier (refer Chapter 3 Herbae nudae and Icontype).

The presence of the whole recognizable form of the leaves and branch in “Illustration of cork cells” Figure 2.11 contributed to the credibility of the cell images and smaller parts. Despite the spatial incongruity of the scale of the plant cells the plant subject was coherent. Within these various representations of cork the decontextualized space accommodates different scales of representation and different visual systems.

As microscopy and biological science developed in the nineteenth and twentieth century the characteristic decontextualized space (of the universal graphic language of the botanical treatise) was challenged.
4.3 Greville’s specimen sheets as tools

First I will discuss distinctive examples from Robert Kaye Greville’s herbarium which are now in the Herbarium Royal Botanic Garden Edinburgh. The titles of the Figures shown here have been taken from hand written notes on each specimen sheet. The note on Figure 4.02 was possibly made by Greville, and refers to where it was found and the collector’s name (“Edwards”); and “with coloured sketch” may have been added by a curator when Greville’s Herbarium was acquired by the Herbarium Royal Botanic Garden Edinburgh. On both sheets Figure 4.02 Arctic Regions Edwards and Figure 4.04 “With coloured sketch 1824” he presented the moss specimen with “a coloured sketch” of magnified details, seen with a microscope. In Figure 4.02 Arctic Regions Edwards on left and right of the top section of the sheet, two moss specimens have been attached to either side of the sheet as if to facilitate an immediate visual comparison of their shape and size. These samples have the leaves arranged elegantly and spread in a triangular fan shape with the capsules sitting atop the fine seta or stalk. Written in ink below the first specimen is the place it was collected, the name of the collector, and date “Arctic Regions Edwards 1824”. The specimen on the right, that is narrower and twice as long, had also been collected by the same person - Edwards 1824.

Lower down on the sheet and clustered across it in two uneven rows from left to right side of the sheet the Greville has shown the microscopic detail of stalk and capsule and has drawn and painted them delicately with watercolour. Greville drew the microscopic detail of the moss, its capsule’s peristome, peristome teeth, annulus, operculum, calyptra, and spores at different magnifications from each other. The magnified drawing of the microscopic detail of the leaf showed the leaf structure and arrangement of cells required for identification. The layout of these images of the parts has a casual feeling, they were grouped neatly together, but they were not formally arranged symmetrically as in plates that are designed for print reproduction such as Figure 4.03 Plate 1V Orthotrichum Art. XXIII. Greville did not include the scale of the
magnification on the herbarium sheet, but the illustration of structures and forms informed the material herbarium specimen and supported its identification.

Compared to the Greville’s herbarium specimen sheet(s) discussed earlier (also plates by Ehret and Bauer figure 3.14, 3.18) and those by Walter Hood Fitch in *Flora Antartica* shown in Figure 4.06) the layout of this uncoloured copper plate engraving has been considered. The space was divided and each was filled with different (taxonomic) orders of the specimen, which are arranged neatly, and clearly show leaf cells. The parts were identified with figure numbers and plainly related the image to its textual documentation. No scale bar was included but the design’s clarity and the layout and structure of the plate was in the recognizable format of information data/knowledge rather than aesthetic qualities.

In the specimen sheet shown in Figure 4.04, the insignificant, light brown coloured moss specimen is presented with a “coloured sketch”. One small dried moss specimen is positioned at the top in the top left corner of the sheet and two thirds of the way down the sheet a watercolour and pencil sketch of its magnified parts are lined up across the sheet. Again on this specimen sheet, the image of the illustrated specimen bears little resemblance to the form or overall appearance of either the living or dried specimens when it is observed with the naked eye. The parts of the moss are fragmented; characteristics that aid identification are the focus, while the appearance of the whole specimen’s form is lost in this representation.

On the left, the segments of red coloured peristome teeth showing the number of segments (divisions) tapering from between eight and two sections at the base, to two at the apex. Alongside are two leaves, the leaf tip pointing to the top. The first of these is lightly painted using a green wash but it shows a yellow halo from the preliminary yellow (watercolour) wash used. This is magnified to show structure of cells and the
costa (spine); an uncoloured pencil drawing of the second leaf shows cell structure on its right side that appears faint and unfinished, with the round shape of knobbly wooden-looking sporangium. All these parts have acquired a distinctive shape, and a decorative quality that would not have been perceived by the naked eye and is not evident from observation of the dried specimen.

As a working document the purpose of the images was to establish the specimen’s identity. Showing the cell arrangement and structure of the leaf along with the dry specimen was a significant part of this process and it allowed for further reassessment. The only text included on this specimen sheet referred to the location and origin of the specimens, Arctic Region, with name and date of the collector Edwards 1824 written below the specimens. In the lower right corner were two botanical names as though Greville has not determined precisely which genus they were either in, Splachnum or Aplodon (?).

This visual analysis demonstrates that Greville’s specimen sheets were tools, references for the scientist in establishing the identity of the specimen. Rather than standing instead of the moss specimen in the herbarium the way that the iconotype does, the painted image of cells and the whole moss specimen presented together, were mutually beneficial for the purpose of identification within the herbarium. These and other Greville specimen sheets with coloured sketches linked his research to numerous print publications (Rix) such as the Plates published in Edinburgh Journal of Science 1824 in Figure 4.03 (Plate 1V Orthotrichum Art. XXIII.)

Observing the herbarium specimen sheets (as a specialist or not) the discrepancies between the different scales and representations of specimen are credible and coherent. The process undertaken by the artist scientist —of collecting analysing and
documenting was laid out clearly on the page, so that it could be recognized as a working document and evidence of the scientific eye.

From 1823 Greville produced and illustrated the monthly publication *Scottish cryptogamic flora* and produced the plates for *Icones Fillicum* (1829-31). The latter was one of numerous publications he co-authored with Sir William Hooker (1785-1865) who until becoming director of the Royal Gardens Kew in 1841 was based in Scotland. The prolific artist Walter Hood Fitch (1817-92) discussed in Chapter 3 and later in this chapter, succeeded Greville and produced illustrations for both Sir William Hooker and his son Sir John Dalton Hooker over a period of fifty years.

### 4.4 Coherence and con-text: purpose image and text

“Pictures cannot assert. While a verbal account need leave us in no doubt that it claims to describe an existing state of affairs, the uncaptioned pictorial representation may just as easily refer to an existing building as a memory, a plan or a fantasy.” Gombrich (175) *The Image and the Eye* 1982

The format and ordering of this plate (Figure 4.06 Walter Fitch Plate LVII) divided into nine equal sized rectangles, is reminiscent of Johann Gesner’s hand coloured engraving of *Class III Triandria* from *Tabulae Phytographicae* (1795-1804) in Figure 3.15. Resembling nine boxes, each rectangle is numbered from Figure i–ix, and within each box is a different bryophyte (moss) specimen. A corresponding textual account described the images for each illustration in a textual account that was printed in a separate section.

Within each box, and across the entire plate, each plant subject has been arranged evenly spread in a decontextualized space. The white neutrality of the background announced the scientific purpose of the ordering and classifying. These small
specimens were represented whole; in fragments; magnified; and clearly labeled and
numbered.

Central to each box were an image of the plant subject—a whole specimen drawn to
scale “of the natural size” (Hooker, J.D.). Each of these complete specimens was
surrounded and dwarfed by the magnified images of the parts. All were shown in their
naturally occurring colours raging through a broad palette of yellow and yellowish-
greens, to reddish browns. The tiny whole specimens at natural size are delicately
drawn to show their distinctively different forms, such as the long and straggling
structure of D. crispulus in Figure IX.1, and the uniformly and tightly packed leafy
structures of both specimens of S. purpureascens in Fig.V.1 and Fig.V.8.

As in Greville’s herbarium specimen sheet with coloured sketch (Figure 4.04 and 4.05),
the colour, structure and form of the drawn and magnified images of these Walter Fitch
plant subjects offers significantly more information about their appearance than the
dried specimens, although to the untrained eye or casual observer this may not be
immediately apparent. Fitch’s drawing of each magnified part of the specimen is
endowed with his characteristic boldness of form and three-dimensional solidity. This
robust quality contrasts with the delicate slightness of the small specimens drawn whole
—at their natural size. As in Greville’s illustrated herbarium specimen sheet (Figure 4.02
and 4.05) a scale of the magnification that has been used is absent. (It is worth noting
that specimens viewed under a microscope are to sections flattened between a glass
slide and cover slip, allowing for identification but reducing the three dimensional form.)

In Figure 4.06 showing Walter Fitch’s “Plate LVII” from The botany of the Antarctic
Voyage, three Figures (“Fig. V, V, VIII) include microscopic detail, including the
geometric segments of the varying structure of the triangular shaped rows of peristome
teeth. “Fig.VI” is typical in not conforming to the format of any other figures on the
plate. A whole specimen has not been shown and the Figure shows a cross-section and greater magnification of and detail of the specimen’s reproductive cell structures. In the following section below (Behind Plate LVII: Visual Textual Descriptions), I will discuss the relationship of the range of representations in images to the textual accounts, and examine the particular detail of cells shown in Sphagnum the Walter Hood Fitch illustration in Flora Antarctica Fig. VI of “Plate LVII” (Figure 4.07).

**Behind Plate LVII: Visual Textual Descriptions**

Walter Fitch’s images in J D Hooker’s *Flora Antarctica* Plate LVII, (Figure 4.06) rely for their meaning and value on the close reading of image and text. Together they were a detailed comprehensive account that described the specimen’s appearance and compared it to similar specimens, and (as in the Greville’s herbarium specimen sheet discussed above), at the outset, specifically located it in geographic terms: “HAB. Campbell’s Island; in moist bogs amongst grass; altitude 1000 feet”

“... Plate LVII. Fig. V.–1, S. purpurescens, of the natural size; 2, a leaf; 3 and 4, capsules; 5, teeth closely approximated in pairs; 6, the same of var. B; 7 the same of var. a, with a longitudinal fissure and some sporules:–magnified. 8, a small tuft of var. B, of the natural size.” Hooker J .D. (Flora Antarctica. Vol 2.)

The textual account in *Flora Antarctica* 1844 (The botany of the Antarctic voyage. Reeve brothers: London, 1844., in the Library Royal Botanic Garden Edinburgh [The Botanics]) provides more than a key to identify the numbered parts of each specimen shown in each of the nine figures (shown in whole plate): it evaluates the variations of the same species and compares them to others. In this instance Splachnum purpurescens on Plate LVII, Fig. V Figure 4.07 (iii) is described in relation to the preceding specimen represented on the same Plate, Fig. IV, S. octoblepharum in Figure 4.06.
“...Nearly allied to S. octoblepharum, but larger, the leaves wider, more distant, less
produced at the apex and more crisped when dry. Capsule narrow and more
attenuated below, with a smaller mouth. In the var. B, both the two lateral of the
longitudinal and the traverse lines on the teeth are very faint; in no instance do the
teeth in this species appear to be really formed of four, the lateral lines always ceasing
before the apex; the lower part of each double tooth is formed by four cells in a line,
but their summits of only two.” J.D. Hooker. (Fl.Ant)

Presentation of nine specimens on the one page facilitated visual comparison of the
characteristics described in the textual account. The tone and language used to
describe and compare the minute details and variations between these small
specimens, was typically speculative and provisional. It conformed to the
methodology of botany as a science based on the relationship between written and
visual record, with- “...unlimited capacity for rearranging its own material, ... so that
there is always the possibility of some new ordering leading to an original scientific
insight”. Crump (5)

**Fitch's Sphagnum: a cross-section and cells (1830s-1840s)**

In Figure 4.08, the image is by Walter Fitch from Plate LVII Figure IV of D.J. Hooker's *Flora
Antarctica 1844* and the specimen shown is Sphagnum. In it a central space is taken by
a magnified image, of a cross section of the sporangium showing the spores inside a
narrow horseshoe shaped chamber around its rim Figure VI.–1. Behind the cross section
is a segment of the specimen’s leaf and its lattice like cell structure. Sphagnum can
produce shoots up to 15cm and it is a much larger species than other species
represented on this Plate. The specimen was drawn at a greater level of magnification
than others and although a scale reference and textual account were absent and
Sphagnum plants features are much more easily distinguished and visible to the naked
eye, this image showed the “invisible” to the non-scientist.
Figure VI.–2. A cross section of the cells showing the structure of cell walls and arrangement of the cells (in the structure); Figure VI.–3 spores; Figure VI.–4 shows leaf tip cells and nuclei; Figure VI.–5 longitudinal section of stem or leaf; Figure VI.–6 cross section stalk. There was no scale reference indicated to evaluate these details.

The appearance of these features and the space they occupy was highly detailed in comparison to others on the Plate, and it used confusingly contradictory styles and scales. Fitch showed the specimen’s parts with naturalistic volume, texture, colour, and included cross-section diagrams. The figure contained like parts of the subject at different scales (spores in figure VI-3 and 1, leaf VI-1 and 4); three dimensional representation of the spores (VI-3 & VI-6); diagrammatic cross section drawing of the cells, one showing nuclei (VI-2, 5 and 4); and the three dimensional leaf with diagrammatic cross section of the attached sporangium (VI-1). This detail distinguished it from the other figures represented on the page and the absence of a scale reference, or a textual account, made its purpose difficult to determine without further research.

Fitch’s inclusion of the cell structure in Figure 4.08 corresponded to other Plates in *Flora Antartica* that included diagrams of cell arrangements of parts of much larger specimens. In these examples the discrepancy in scale was comprehensible and the two images informed and verified each other clearly. Fitch’s application of this method to the very small specimen in Figure VI illustrated the limitations of the graphic conventions he used to recombine coherently the multiple scales of magnification of the subject into a coherent image. Although without the framing shape of the lens, and against the white background of the decontextualized space, the cell structures in the plates of *Antarctic Flora* corresponded closely to Robert Hooke’s image of cork cells in *Micrographia* from 1644 in Figure 2.11.
Greville’s specimen sheets in the Herbarium Royal Botanic Garden Edinburgh (Figure 4.02, 4.04) and the Plate 1V Orthotrichum Art. XXIII of the Edinburgh Journal of Science 1824 (Figure 4.03), JD Hooker’s textual description of specimens and enumeration of the cells in the pyramid shaped “peristome teeth” for the plates in Flora Antarctica (1844), and Fitch’s image of Sphagnum Plate LVII Fig. IV figure 4.08, (showing the spores within the sporangium and the structural divisions in the peristome teeth), all illustrated the value of seeing and recording microscopic detail of structure and arrangement of the cells for their particular taxonomic endeavors. This may have been sufficient resolution for their purpose, at the limit of their instruments’ optical capacity, and or their respective microscopy skills. The botanical conventions employed by Fitch accommodated the cell images well enough for their purpose (to name and identify new and known moss species) in the context of the botanical research for which they were produced. The technical possibility of seeing and representing greater detail within cells (other than their structure and arrangement), developed into biological science with a radically different set of graphic conventions to those used by Fitch and the artist scientists discussed here, who worked in the early to mid-nineteenth century.
The Compound microscope consists of a lens of short focal length for forming an image that is further magnified by a second lens of longer focal length. Collins English Dictionary, 310

Ehret's illustrations of Linnaen taxonomy.

Brown work in Illustrationes Floraes Novae Hollandiae, London, (1813-16). Hewson (72) notes of the brothers that Ferdinand Bauer's expertise was with the "macroscopic level" while Franz was skilled at "portraying the microscopic detail" and his headstone is inscribed -"in microscopic drawing he was altogether unrivalled and science will be ever indebted for his elaborate illustrations of animal and vegetable structures."

This research was an opportunity to extend the background work to this project: the artist book and series of 15 digital prints Fruitingbodies 2000, and the installation Groundcover 2000. This work was based on the way the late Dr. Antoinette O'Neill University of Wollongong had used data visualizations (satellite images and electron micrographs), to study vegetation in the extreme environment of Lake Mungo, NSW.

The size of mosses (bryophytes) varies widely, the mosses shown on Plate LXII range from a few millimetres to 35mm. Glime (3) discusses mosses of a few millimetres such as Ephemeropis and Viridwvellus pulchullum and hummocks of Polytrichum commune which are greater than half a meter in height. Dawsonia superba up to 70 cm has tall leaves 35mm high and Fontinalis is supported by its water habitat growing to 2 meters in length.

Greville Herbarium now in Herbarium Royal Botanic Garden Edinburgh (RBGE) Dr. Robert Kaye Greville (1794-1866) provided the plates for Icones Filicum 1827-32 jointly published with Sir W.J. Hooker & R.K. Greville. Other publications include his publication in 1823 of the monthly Scottish cryptogamic flora illustrated with his own drawn and coloured plates and "Flora Edinensis" (1824) and "Algae Britannicae" (1830). Based in Edinburgh Greville toured parts of Scotland in 1834 and 1837 collecting specimens for the Botanical Society. In addition to his botanical work he opposed slavery and served as an anti-slavery delegate to the Colonial Office. In 1834 he made a tour of Sutherland and again toured in Scotland in 1837, each time collecting specimens for the Botanical Society.

Distinguished botanist Sir William Hooker held the chair of Botany at Glasgow University, and in 1841 he was appointed Director of Royal Gardens Kew and for 10 years, from 1815 sole draughtsman for the illustrations in Botanical Magazine and also of the new edition of Curtis's Flora Londinensis (1817-28) and Flora Boreali-Americana (1829-38). "The fact that such distinguished botanists as Hooker, Herbert and Lindley were prepared to "turn artist" is also evidence of the advantage to be gained from the keenness of observation acquired by such work, especially where it involved the drawing of dissected flowers enlarged." (Blunt, 264)

"Some idea of Fitch’s gigantic industry can be gauged from the fact that 9960 published drawings by him are recorded by W.B. Hemsley (Kew Bulletin, 1915:277). Illustrations for at least thirty five books and five periodicals." Blunt (264).

Class III. Triadria from Tabulae Phytographicae (1795-1804).

The peristome teeth are located around the opening of the apex of the sporangium, the bulbous shaped sporophyte that emerges from the leafy gametophyte. They respond to moisture and regulate the distribution of spores (from the sporangium).

Compare Figure 4.03 Plate IV Orthotrichum Ant. XXIII. Journal of Science Hooker & Greville, 1824.
Chapter 5 Over the Rainbow

Summary

In Chapters 3 herbae nudae and icontype and Chapter 4 Foreign Musci I have compared the early printed herbals of the fifteenth and sixteenth centuries to the botanical treatise of the eighteenth and nineteenth centuries. The images discussed reflected advances in printing and image reproduction technology that were significant for the dissemination of new botanical knowledge—wood block, copper engraving (detail), and lithography (of Walter Hood Fitch). The discussion examined the relationship between changing print technology, the development of new graphic conventions, the collaboration between artists and publishers (Weiditz and Brunfels), and artists and scientists (Ehret and Linnaeus, Bauer and Brown, Fitch and the Hookers). The specific purposes and value of these images (as standing for the real thing in the herbarium) were described along with their relationship to textual accounts as well the significant status of images through the use of a universal graphic language.

Introduction

In this chapter I examine the graphic conventions that developed in the nineteenth and twentieth centuries to accommodate the demands of optical technology of photo microscopy; electron microscopy (SEM and TEM) and confocal microscopy (visualizing sub-cellular functions and processes); and explore how changes to the purpose and the value and meaning of visual material for artists and scientists change the status of images and visual representation for artists. The inherent ambiguities (of fact and invention) of naturalistic representation are accentuated by the effect of optical technology on the veracity of data and its visualization by contemporary twenty-first century artist-scientists. (The effect of optical technology and the regard for images and visual experience, evokes aspects of the earlier shift, “the rupture between
image and text that occurred in the transition from illuminated manuscript to printed books”, described by Dickenson that I discussed in chapter 1.)

"In many cases there is no way to compare a representation of a biological phenomenon to the “real” thing, since the thing becomes coherently visible only as a function of the representational work”. (Lynch qtd. in Dickenson 234)

The images of plant subjects discussed in this chapter are the result of developments in optics, other instrumentation, and areas of science that developed between the seventeenth century and the present. Small plant specimens and cell images observed at microscopic and ultramicroscopic levels present phenomena (processes) that are not visible to the naked eye. These images depart from the recognized language of visual truth and accuracy that was established by artist-scientists of natural history between the seventeenth and nineteenth centuries (e.g. by Merian and Fitch’s botanical accounts, and in the botanical treatise discussed in Chapter 3). The empirical and aesthetic qualities of contemporary visualizations challenge the graphic conventions established by these earlier artists.

In analysing the graphic conventions that characterize these microscope images and comparing them with the universal graphic language of botany described in the previous chapters, the discussion considers differences in their value and purpose and the implications for the way visual material is regarded once the new instruments came into use from the mid-nineteenth century.

Images of cells and visualizations of minute phenomena that occur within them at ultra microscopic dimensions represent not only changes for the status of visual material, but a significant increase in the role of instrumentation. Along with its own new graphic language, the technological developments for observing, measuring and imaging, are characterized by a different use and purpose. Identifying the (new) language used in
visualizations and the phenomena represented, the discussion examines the lacunae between the veracity and authority of the images, and the relationship between different images and their value. The chapter does not attempt to survey or describe a comprehensive history of technology and science in the nineteenth-twentieth centuries, but pinpoints salient areas for discussion in analogue, digital microscopy, and photography.

5.1 Insight from botany to biological science (Robert Brown nuclei)

“...scientific images do not, of course aim at recording what is visible, their purpose is to make visible” Gombrich (246) The Image and the Eye 1982.

Although von Leeuwenhoek in the seventeenth century had observed the cell nuclei a contemporary of the Hookers, Greville and Fitch, the Scottish botanist and highly skilled microscopist Robert Brown (1773-1858), was the first to name the nucleus and document its occurrence within the cell (Ford 2). Robert Brown had collaborated with Ferdinand Bauer on the Matthew Flinders voyage to Australia (their work is discussed in Chapter 3). The combination of his work on taxonomy and his observations of cells make him a significant connection between the universal graphic language of the botanical treatise and the visualizations of biological science with its own language of microscopic and ultra microscopic phenomena.

During the first part of the nineteenth century microscopes were improved with “achromatic objectives by van Deijl, Amici and Lister [and] the advanced glass formations by Zeiss, Schott and Abbe who helped produce the first apochromat-objectives”. A modern light microscope resolves to 200 nanometres (nm), or 1,000 times better than the human eye, while the magnification and resolving power of early nineteenth century microscopes was limited. Figure 5.01 shows the “primitive instrument” used by Robert Brown, and Figure 5.02 is the reproduction by the
independent scientist and author Brian Ford of what Robert Brown was able to see with it in 1827. The Orchid epidermal cells viewed under Brown’s microscope, shows the nucleus within each cell, with three stomata also visible.

Using this simple microscope Robert Brown identified not only the nuclei of cells but also observed the movement of minute particles within vacuoles in pollen grains and spores of mosses. This resulted in his description of the phenomenon of “Brownian Movement”, now referred to as “Brownian Motion” (Ford 235). At the time, his observation was received with scepticism, but in his recreation of these historic observations Ford commended Brown’s expertise as a microscopist;

“... an accomplished technician and extraordinarily gifted observer of microscopic phenomena ... [these are] difficult observations to make with a modern instrument even with the benefit of hindsight” (Ford 236).

Brown’s new insight of the nuclei and other minute phenomena, was a shift from seeing structure, to observing understanding and visualizing function and process in movement (“Brownian Motion”). It is a challenge to the graphic language of nineteenth century science in a way that corresponds to those (challenges) faced by artists-scientists of preceding centuries (chapters 2 & 3) who developed a graphic language to describe and catalogue the abundance specimens of the New World.

By the middle of the nineteenth century, within ten to fifteen years of the publication of Fitch’s cell image in Figure 4.08, August Köhler’s use of Abbe’s objectives allowed for the development of Photomicrography (Davidson). The history of the social and cultural implications of optics and subsequent technological developments in the nineteenth and twentieth century, have been extensively documented by Crump (and other historians). For this discussion, it is images and visualizations of “biological phenomena” that occur outside the visible spectrum and become visible only through representation
using (analogue and digital techniques) of optical technology that are significant for this study.

**Hooke’s juices: the space of the cell and cell structures (Wilson & Tagawa)**

“...light microscope can never resolve detail finer than about 0.2 µm (nanometer)- the size of a small bacterium... The resolution is limited by the wave length of visible light used to illuminate the specimen. Light microscopes can magnify effectively to about 1000 times the size of the actual specimen; greater magnifications increase blurriness” (Campbell 111.)

Hooke’s magnified cork cells resembled a honeycomb. Eminent cell biologists Brian E. Gunning and Martin W. Steer in *Ultrastructure and the biology of plant cells* (1975) describe Hooke’s view of them as “… empty spaces delineated by walls” (7); and biotechnologist and author of *Introduction to Botany* (2004), Murray W. Nabors suggests that the image Hook saw “ reminded him of monks’ cells” (26). Even though Hooke and others acknowledged something, “juices”, to be in these spaces, the cell came to be defined by this observed structure rather than the substance it contained. Reinforcing this idea of cells as structure, in 1839 the zoologist Theodore Schwann (1810-1882) “described the cells in cartilage as resembling the parenchymatous cells of plants, ...and (this) is commonly regarded as the inception of the theory that all biological material is composed of cellular material”7 (Gunning and Steer 7.)

Gunning describes this early attempt to define the cell as incorrect. Though the botanist Schleiden (1804-1888) pointed out to Schwann that all plant and animal cells share other features – such as the nuclei that Robert Brown had identified, he was also mistaken when he defined the cells as “ nucleated, walled structures”. In the following
decade both Jan Evangelista Purkynje (1787-1869) in 1840 and Hugo von Mohl (1805-72) in 1845, “independently applied the term protoplasm to the substance that was between the nuclei and the cell walls. Further understanding of the function of this substance by Rudolf Virchow (1821-1902) led him (in 1858) to contradict the idea of spontaneous generation (that non living things could give rise to organisms) with the realization that “every cell originates from another existing cell like it”8.

“We now know that protoplasm (which includes the nucleus) is the basis of all cells, and that the walls formally regarded as the unifying feature, are a product of the protoplasm of plant, not animal cells. In short, the emphasis has shifted from the walls that surround spaces to the content and substance of these spaces. The word cell has been retained, but refers to the protoplast (consisting of protoplasm). The cell wall, where present, is relegated to the status of an extracellular product of cellular activity.” (Gunning and Steer 7)

Improvements to optical instruments and the techniques for observing and recording the processes within cells (Hooke’s “juices”) extended the concept of cells from structure to function. The visualization and representation of the functions occurring within cells and at molecular level extends the parameters of this discussion from botany to biological science. This change of emphasis—to the visualization of sub-cellular9 phenomena, and the range of technology(s) that supported it10, signalled the demand for a new graphic language.

In his early work the American cell biologist Edmund Beecher Wilson (1856-1939) presented his findings in cytology photographically11, but reverted to drawings which could more accurately distinguish different features (Maienschein in Flannery 199). In her recent analysis of cell images, biologist and educator Maura C. Flannery (1998) states that Wilson’s schematic drawing of the cell (Figure 5.03) became influential and
endured in biology texts for nearly forty years, 1925–1962. The sustained use of this abstract and schematic drawing over such a long period of time (when significant developments were taking place in microscopy and cell biology), has been attributed not only to its aesthetic qualities and empirical value, but also to the authority conferred on it by Wilson’s reputation and status in his field. Flannery (195) notes the similarity between the reuse of this image and the practices of publishers and printers of earlier illustrations – and cites the sustained credibility of images such as Albrecht Durer’s 1515 woodcut Rhinoceros that was copied and reinterpreted over a period of 200 years.

In their respective discussions of images (and of the versions of Durer’s print), the writers Dickenson (60), Gombrich (Art and Illusion) and Saunders, have all described ways in which artists contending with new visual new material (subjects) rely on previous experiences and known references: “The familiar will always become the starting point of the unfamiliar” (Gombrich 72), and that “How and what we see depends crucially on what we know” (Saunders 12). Although their statements suggest a stultification or torpor, and this tendency is associated with manuscript copying and early woodblock herbals discussed in Chapter 1 and 3, the role of optical technology and changes to their “dominant purpose” Gombrich (13), can be considered as catalysts in the process of refining and developing images and the graphic conventions that have been used. It is worth noting here Merian’s correspondence in 1702 to her friend Johann Georg Volckamer that she was seeing and painting “many amazing rare things that have never been seen before.” (Owens 151)

The aesthetic quality of Wilson’s diagram / drawing as described by Flannery and others, is its simplicity and clarity enhanced by the use of black and white. Not only is the clarity reinforced by the absence of volume there is “pleasing tension between symmetry and asymmetry” (Flannery). The nucleus, central body, and Golgi bodies are
clumped in a vertical row towards the top of the cell’s ovoid shape. Other features are evenly located at the bottom of it and the vacuoles, plastids, and chondriosomes are arranged in a balanced pattern throughout the space of the cell. Wilson includes the cytoplasm “as a mesh-like network similar in appearance to a colloid such as gelatin when it begins to dry”, but its uniform appearance “does not reveal crystalline or fibrillar structure that others had speculated about but for which there was little evidence” (195).

Wilson’s cell has significantly more detail than Hooke’s cork cells and far less than Gunning’s cell diagram Figure 4.15, as Flannery points out there is “not too much detail”. The ordered composition of the cell components, as well as the fact none of these features overlap each other, and are also contained within a smooth and regularly shaped oviform enhances the schematic quality of the image. Wilson’s exclusion of the complicating structures of cytoplasm here recalls the approach of artists to the images of plant subjects in the botanical treatise in the eighteenth and nineteenth century. Images in botanical treatise selectively emphasise, include, and arrange plant subjects to best represent theories of classification (refer Chapter 3).

The aesthetic and empirical quality of the Wilson cell image, and its reuse in reference texts indicates its value as a teaching aid. Flannery notes that although Wilson did “not espouse (to) mechanism” its slick style “– smooth lines and symmetrical components are reminiscent of a machine.” But unlike a machine its fixed static quality does not resemble the actual dynamic properties of living cells. The preparation required to maximize (seeing) visible structures within cells requires specimens to undergo processes of staining, fixing and embedding. Though some stains can be used on living cells, most of these procedures are applied to fixed or non-living cells and prohibit the possibility of seeing dynamic processes. This paradox of microscopy has been noted by Flannery. (For discussion of dynamic processes refer to: confocal microscopy
As with the sustained use of Wilson’s 1925 cell in textbooks, Bunji Tagawa’s drawing Figure 4.13, published in 1961 was repeatedly used in texts throughout that and following decades, with coloured versions as late as 1989 (Flannery 197). Though a contrast to the simplicity of the former, Tagawa’s representation reflects the additional detail that could be observed with the electron microscope that had been in use since the 1930’s. Although almost a rectangular shape, the profile of the contour in Tagawa’s cell suggests an organic and irregular form (an animal cell as plasma membrane not confined by a wall). A grey “stippling tone” accounts for cell parts that are beyond the limit of this microscope, and seeming to float within it, the internal cell structures and their names are clearly presented. Flannery attributes its appeal to the aesthetic qualities – its parts “are clearly delineated …the composition is not crowded”, and it is characterized by simplicity, “clarity and balance”.  

The Wilson and Tagawa cells are defined shapes within a neutral decontextualized background – able to be scrutinized similarly to the presentation of a plant specimen in a botanical treatise. The simplicity of their parts, the absence of volume or three dimensionality confer a schematic and map like quality that recalls Hooke’s cork cells.  

Drawing techniques allow for desired features of the cell to be edited, highlighted, and clarified, by both these artists discussed here. The next part of this discussion examines cell images defined by a range of technological tools, and it examines some of the ways instrumentation contributes to mediating the characteristics of the graphic language – to incorporate not only new techniques and tools for artists and scientists, but a radically different visual language and regard for images.
5.2 Subcellular phenomena and visualization: new graphic language

“Photography allied with other technological tools – microscopes, scanners, and computers has allowed science to explore aspects of the physical nature of plants hitherto invisible” Saunders (148), *Picturing Plants: An Analytical History of Botanical Illustration* 1995.

From the sixteenth to eighteenth centuries Maria Sybilla Merian’s images in *Metamorphosis* (Chapter 2) and others (such as Albrecht Meyer’s Crocus Figure 3.11 and Ehret and Bauer’s plates in Figures 3.14, 3.17), certainly show dynamic changes to their subject’s form and discrepancies of scale. Remarkable detail and visual accuracy was also shown in Robert K. Greville and Walter Hood Fitch’s work discussed earlier in Chapter 4. The phenomena they observed and represented could be accommodated by techniques of naturalistic representation and the development of particular graphic conventions, - perspective, decontextualized space, volume, and naturalistic colour (Refer Chapter 2 and 3).

Since the early nineteenth century the greater insight offered by developments in instrumentation using analogue and digital techniques, different fields of science, optics, and image generation have all contributed to the paradox of microscopy discussed in earlier chapter (the impossibility of calibrating the visualizations of microscopic phenomena). Referring to the heuristic value of representation, the use of “diagrams, photographs and digital imagery” in science, Dickenson (243) suggested, “...it is tempting to postulate that the use of images as information occurs at points when the data are too complex for simple verbal transcription”.

In Hooke, Greville, and Fitch’s cell images discussed earlier (Figure 4.09, 4.03, 4.08) a naturalistic image of the whole or recognizable portion accompanies the microscopic fragment. This combination (accentuated in Hooke’s plate by the inclusion of the lens
shape framing), overcomes the contradictory scales, and the spaces they occupy combining two-dimensional cells and the form and volumes of the three dimensional representation. Together they contribute to supporting the interpretation and recognition of purpose (of the cell images) in the image.

Although the relationship between the cells and the specimen is evident and presenting them together gives credibility to the image, it is not shown just how much the sample has been magnified. Campbell explains – “magnification is how much larger the object appears relative to its real size. Resolution is the measure of the clarity of the image” (111). To illustrate the significant difference between magnification and resolution offered by the “performance” of light and electron microscope Gunning (2) points to images of Light Microscope image Plate 1 The Plant Cell (1) Figure 5.07, and Transmission Electron Micrograph Plate 2 Figure 5.08 and that, “Increasing the magnification of Plate 1 (light micrograph) by a factor of five until it had the same magnification as the first electron micrograph (Plate 2) ... would not yield comparative detail”.

5.3 Space: cell images as maps (Figures 5.05, 5.06)

Describing the capacity of nineteenth century technology and the first X-Ray image in 1895 by Wilhelm Conrad Roentgen (1845-1923), the artist, writer and historian of art and science Amy lone in her essay “Images and Imaging” refers to “non-optical images” as: “graphic renderings of invisible domains, the non-optical images are maps capable of placing ‘something’ in the portion of the spectrum used by our eyes, but something that could not be seen without the new technologies.” (Ione 95.)

Reading such maps recalls Marsha Meskimmon’s statement (quoted in the introduction of this thesis), on the significant relationship between representation and
the power of (specialist) knowledge. Dickenson emphasises the idea that “representation permits interpretation”, and cites Michael Lynch’s “careful analysis of the relationship among diagrams, photographs, and digital imagery that visualization of complex data provides not only understanding, but also mastery” (243). The complex function and the significance of both data and images to elucidate (new knowledge) in post-modern20 science further compounds the paradox of microscopy (trust /sight) discussed earlier in this chapter.

The focal length of compound microscopes is very narrow and Gunning’s diagrams Figure 5.05 and 5.06 demonstrate not only the specialist knowledge needed to interpret the forms and relationships between the parts of the cell in a projected image that results from ultra-thin sectioning21, it also indicates the relationship between different images of the same phenomenon. A comparison between “[c]” in Figure 5.06 and Figure 5.06 highlights the complexity of the phenomena and the limitation of singular representations of it. Gunning describes Figure 4.15 as “stylized three-dimensional interpretation of that mythical entity, the typical plant cell... (is shown as being) artificially symmetrical and simplified”. This 1975 diagram, which edited and simplified the components of the cell and “for clarity they are not drawn to scale”, showed the inherent difficulty of interpreting the projected image (map) of a section (such as Figure 5.06 “[c]”) of such a complex phenomenon22.

Though the space of the diagram is complicated and filled -up, the aesthetic quality of the cell image in Gunning’s diagrams shared the defining, order and clarity of Wilson and Tagawa’s cell drawings (of 1925 and 1961 respectively). Their purpose and value is in knowing - explaining and describing the complex components of the cell and their relationship to each other, and in supporting and articulating the meaning to other images (of cells) such as the photomicrographs.
The absence of volume, decontextualized-space and colour

Gunning’s images together with the extended captions describing them, serve to highlight the different way space, colour (and tone) are used to describe the specimen at these magnifications. In addition to the change in the graphic language, singular images are unlike the complete and definitive images of the botanical treatise or herbarium icontype (Chapter 3). The value of these twentieth century (microscope slide) sections and images is their profusion. “Sections are statistical samples of cells and tissues, and it is not to be expected that any one view of a cell will contain all the components.” Embodied in the multiplicity of the cell images is both fragmentation of a whole, and the absence of a definitive sample-image.

5.4 Filling Hooke’s void

Of the image of this light microscope image Plate 1 The Plant Cell (1) in Figure 5.07

Gunning explains,

“Large cells in the meristematic\(^{23}\) region of a broad bean (Vicia faba) root tip are viewed by phase contrast microscopy...The magnification is x 4200, i.e. 4.2 mm represents 1\(\mu\)m, and since the thickness of the section was about 1\(\mu\)m, we are in effect looking through a slice 4.2 mm in thickness, rather than an infinitely thin 2-dimensional picture.” (184)

Although as Gunning says here, the slice is not “infinitely thin”, compared to the graphic language of botanical drawing, the specimen is apparently without volume. No longer is the specimen a subject objectively located in a neutral decontextualized space. Magnification is confirmed even without Hooke’s lens shaped framing, as the specimen extends to the boundaries of the (rectangular) shaped image. Even without reference to textual description of the dimension, a sense that the specimen extends beyond the edge of the plate confirms something of the paradox of representing the non-optical
scale. The void of Hooke’s cellular structures noted earlier in this chapter has itself become the total image.

The absence of volume combined with the wall-to-wall space in the transmission electron microscope (TEM) cell images (in Figure 5.08 and Figure 5.09), resemble more closely the vast terrain of a landscape recorded with an aerial photograph where scale is disproportionate to experience, rather than the microcosm of a cell. In the transmission electron microscope (TEM) images with resolving power “about one thousand times greater than that of the optical microscope... – the three dimensional architecture of cells and cell components has been magnified into the range of our ordinary senses” Both images further illustrate the mapping and contextualization of space in the visualization of this data. (Gunning page 2 description of TEM method)

Commenting on the inherent problems of interpreting and visualizing dynamic processes of cells which have been through the preparation process of fixing, embedding, and sectioning, Gunning (2) makes the following analogy.
“Using a section of 0.05 µm in thickness to investigate the architecture of a cell 20 µm in diameter is like trying to describe a house, its rooms its cupboards and all their contents down to 1 mm in size by examining a 2 cm thick slice of the whole building.” The reconstruction of such thin sections from two-dimensional sections into “three dimensional reality” demands many sections and “these to be cut in known planes or sequences from which three dimensional reconstructions can be made.”

Gunning’s caption for the transmission electron microscope image Figure 5.08 described the difference in its magnification to the light microscope image in Figure 5.07 Plate 1 The Plant Cell (1).

“This section sliced through the mid region of a cell in a root tip of cress (Lepidium sativum), and viewed here through electron microscopy at X20,000.
The section was about 75mm thick, so at this magnification the slice is almost 1.5 mm thick—relatively thin compared to Plate 1.” Gunning 186

Compared to the flat and map-like appearance of the thin sections of cells shown in light (LM) and transmission electron micrographs (TEM) Figures 5.05-5.06 is the volume and the surface detail of scanning electron micrographs (SEM) in Figure 5.09. Instead of looking onto the mapped TEM image, the SEM cell images appear as a three-dimensional landscape, the deep space and volume is reminiscent of an immersive underwater world of a scuba diver. The SEM image is convincingly familiar, the extraordinary forms, shapes, textures, decorative details, heightened colour, and sharp clarity of the sample, resemble the experience of seeing sunlight coral reefs through clear water.

Flannery (199) concluded that, “no image of a cell is perfect, each type of imaging provides different kinds of information.” Gunning shows this in Plate 6 (Figure 5.11) where he inserts three-dimensional SEM image details into the TEM Plate. The flattened space of a thin section in the map-like TEM, and the three-dimensional volume of the SEM illustrates not only the difference of microscope techniques— but the value of exploiting and employing both map and mirror to optimize the description.

The authority and authenticity micrographs confer on a cell image (and they have been used in cell imaging since the 1800s [Ford 2]), is deceptively ambiguous and belies the extent of mediation by the technology, and intervention that occurs at all levels of the processing, colouring the specimen through staining, as well as the resulting image.
5.5 Colouring in

Although the challenge of accurately representing and reproducing naturalistic colour for artists like Merian and Bauer was significant, colour was not the concern for showing the structure of the cell in illustrations by Hooke (seventeenth century), or for Wilson in the twentieth. The latter’s cell structures were delineated in black and white, and a range of tone and texture defined the cell’s structures and forms with clarity. Colour in the visualizations of microscopic phenomena is a significant departure from the naturalistic “true colour”\textsuperscript{26} of the visible spectrum experienced by the human eye and replicated as accurately as possible by artists in the botanical treatise.

The use of colour in observing and imaging the microscopic dimension has a range of aesthetic and empirical aspects. Colour is introduced to specimens to reveal different characteristics and it is applied to images in order to represent these. Some light microscope images have natural colour and can appear green, as the cells seen in Figure 5.12 (a) show, others such as 5.12 (b) shows a light microscope image where stain reacts with chemicals of the lignin\textsuperscript{27} molecules, dying them a pink-red colour.

Transmission electron micrographs and scanning electron micrographs are characteristically black and white showing the electron density of the specimen, and stains are introduced to the specimen to highlight, emphasise and define particular chemicals and show the structure and form of the cells\textsuperscript{28} as in the Scanning Electron Micrograph Figure 5.12(c).

In confocal and fluorescence microscopy shown in Figure 5.13 (the microscope) is reading, collecting and interpreting the (colour of) wavelength bands, and visualizations of these are artificially modified and coloured by the microscopists to define structures and functions of substances being represented (Hooke’s juices). Colour is determined and applied by illustrators and animators in developing digital
and analogue visualizations, as in David Goodsell’s drawing (Figure 5.15) and Drew Berry’s recent animations of processes such as DNA unravelling (Figure 5.16) and *Apoptosis* 2007 (Appendix 2).

The complex purposes of colour indicated here show it can be an empirical and aesthetic tool as well as an inherently subjective perception. As greater insight is achieved so too its “true false” ambiguity reinforces the paradoxical nature of cell images. Ironically, to produce the black and white image of the cell structure in Figure 5.07 Plate 1, the specimen was stained to define and differentiate the density and properties of the specific parts (such as the nucleus cell wall).

“The section was reacted with acriflavine, following oxidation in periodic acid, to stain carbohydrates yellow (e.g. in the cell walls and starch grains), and subsequent immersion in another yellowish reagent–iodine in potassium iodide–gave a generally stained preparation, best examined using blue light.” (184) Gunning’s precise description of the technique used to stain the section (of cells) to enhance visualization in the 1970s (of a colourless specimen for using in phase contrast microscopy), indicates how colour has a central role in creating an image that differentiates tone, defines, and highlights features of the cells selected by the microscopist. The specimen (and the resulting image) has been manipulated similarly to the way in which Wilson in 1925 and Tagawa 1960 emphasised and selected features in their images of cells.

In common with the EM SEM and TEM images discussed so far - colour is integral to the (monitor) image produced with the confocal microscope. Unlike the processes of specimen preparation: staining, fixing, and embedding that (usually) kill cells, the confocal microscope allows for a live specimen to be observed. Readings and measurements of the live specimen show functions and process occurring within the living cell. In this example, pigment in particular areas of the specimen respond to the
concentrated beam of the laser. The artist-scientist, technician-microscopist is able to select specific areas within the specimen and see the (cellular) processes, in this example chlorophyll florescence of chloroplasts indicates levels of photosynthesis in moss.

In this instance (2003) the images made by Andrew Netherwood are evidence of plant health and cell damage. Their value is their relationship and context to wider research where these indicators can be examined further, using other types of laboratory techniques or matched with data collected in fieldwork. They are a working document and tool in a similar way to Robert K. Greville’s herbarium specimen sheets with their coloured sketches. However these techniques and their images are a radical departure from the graphic conventions that Greville employed. Multiple images representing temporal processes at these levels of resolution and magnification recalls Lynch’s statement of the impossibility and irony of some images,

“In many cases there is no way to compare a representation of a biological phenomenon to the “real” thing, since the thing becomes coherently visible only as a function of the representational work” Lynch in Dickenson, 234

Anne Cleary’s recent “research work and visualizations”, as well as elucidating Lynch’s statement, reiterates the relationship of images within the wider research context. Her technique of confocal laser scanning microscopy “is significant for understanding cell division” (Cleary 5). The value of the sequence of video frames figure 5.14 and 5.15 for this (cell) research exemplifies the capacity of images as multiples to represent temporal phenomenon — a technical practice beyond the scope of preceding graphical conventions.
5.6. Veracity and value of images

“any phenomena which are difficult to conceive in term of any visual image”

Crump (45)

The proliferation of empirical information and observational data produced by current scientific research increasingly encodes in the visual what cannot be presented by other means. Similarly, our experience of it is encoded too, presenting as a naturally digitized environment, of simulations, virtual reality, and virtual truth. In interviewing the biologist and animator Drew Berry, Place quotes his (Berry’s) description of the parameters that characterize invisible domains “A lot of molecular actions happen at a speed scale that is meaningless to us”. The challenge of creating, deciphering and interpreting the images of nature mediated to this level is complex: and when artists and scientists begin to contend with the phenomena of Crump’s post-modern science and combine it with digital imaging tools they are reinterpreting nature as well as the nature of representation. Digital techniques offer a visual empiricism to science through microscopy and spectroscopy, but in contemporary visual art practice this veracity can be exchanged for verisimilitude. The former is undermined by the tools of image manipulation with its relative ease, speed, and access to the computational tools of transforming, combining and seamlessly altering material.

In his systematic study of the way images are understood and used William J. Mitchell reconsiders photographic truth in the context of new technologies. Photographic manipulation has always been possible but as Mitchell states “extensive reworking of a photographic image to produce seamless transformations and combinations is technically difficult, time consuming, and outside the mainstream of photographic practice” (7).
The plethora of images and the ease and speed of their production is enhanced by digital computation. When this is coupled with their veracity as visualizations of data, they are at odds with the readings of nature and the significance of images in earlier contexts. This includes the singular definitive icontype in the herbarium (refer chapter 3), and Merian’s accounts of metamorphosis (see chapter 2). As the “empiricism” of visualizations of data on the scale of nano-technology increases and takes form in virtual worlds, the spectral, spatial and dynamic characteristics are reinterpreted. Simultaneously, the credibility of their aesthetic and graphical properties is altered and diminished in terms of the conventions established by earlier artist-scientists. While their images may have been less uniform, reliable, or accurate than data based visualizations they were generally comprehensible and identifiable to a non-specialist.

Artist-scientists such as the animator-cell biologist Drew Berry (b.1970- ) and painter-crystallographer David Goodsell construct visualizations and fabricate visual accounts of phenomenon (refer Figures 4.25, 4.26 and Appendix 1). Goodsell interprets the gap between (data of) molecular forms of X-ray crystallography and cellular organelle forms of electron microscopy (Flannery), to produce works “of imagination grounded in quantitative analysis of specific molecules and cell types” (197).

Conflating the empirical and aesthetic, these artists employ a range of means and media, what Elkins refers to as,

“the variety of pictorial means: from photographs to computer graphics to hand-drawn pictures, from geometric abstraction to organic approximations, from scales to perspectival views to projections, [from shaded pictures to wire-frame schemata].” (569)

Goodsell combines traditional and contemporary methods—“Some are created with computers, using 3-D graphic programs. But many others come about ... with watercolor and brush. The idea is to synthesize a view of something not accessible by
any other means. Computer graphics, illustration and artistic interpretation provide a
to see what Goodsell creates” it is a
 reminder of Elkin’s suggestion that these types of images reconnect “with the ways that
pictures (of western art history?) are used to try and see what can never be seen”.
Berry’s comments (about his animations) align with this too when he makes the
following statement: “The molecular world is so small, it can’t be seen. I’m painting
pictures of what the world is like down there.”

Explaining the central role of visualization in his scientific work Goodsell describes that it
is critical for him to “see” the shape, structure and components of the virus. “It’s
completely visual. It’s modelling the 3-D structure of the drug to the 3-D structure of the
virus, then grappling with the essential components” (Fenley). Of his animations for
body code 2003 at the Australian Centre for the Moving Image Berry states that “the
biggest bio-molecules are resolved as static blurry shapes, with scientists relying on
other techniques to determine how they interact… Drawing upon this fragmentary
evidence from all fields of biomedical research, my quest is to holistically construct the
most accurate and insightful visualizations of cellular and molecular worlds that have
ever been produced. With clarity and detail never before seen…”33. The clarity and
detail Berry seeks are what Maria Sybilla Merian wanted: notwithstanding the centuries
between them, some aesthetic notions persist.

The static diagrammatic quality of the early-mid twentieth century drawings by Wilson,
Tagawa and Gunning (figures 5.03, 5.04 5.06) have a mechanistic authority that is
accentuated by the simplification, clarity and ordering of the forms. While the value of
these aesthetic considerations enables the images to function for a specific purpose,
the cells were presented as uniform static entities and were likened to small machines (Flannery 196). In comparison to these is Goodsell’s three-dimensional black and white drawing of *Escherichia coli bacterium* magnified to one million times. Rather than the subject being positioned within a white decontextualized space the drawing resembles the micrograph where shapes and forms meet the frame (and Hooke’s lens shaped framing too). The interplay of a variety of organic forms and shapes create an interconnected structure, offering a dynamic interpretation of the cell, so that the image implies the processes of a living organism. Flannery describes the space within the cell walls as “A cellular environment: molecules and organelles are packed together”, and Fenly quotes Goodsell himself who says, “I’m always struck by the incredible complexity of cells and yet the inter-connectedness of it all. There’s such detailed structure on the gross scale and such randomness on the small scale”.

As if picking arbitrarily from the array of visualizing tools and techniques, both Goodsell and Berry have been opportunistic in their choices of graphical means for representation and interpretation of spectral characteristics. Goodsell’s colour clarifies, defines, and simplifies the complex colourless molecular world. Flannery explains “proteins in shades of blues, nucleic acids in shades of purple etc. The addition of colour makes the image more informative and even more visually attractive” (197). For Drew Berry the choice is unequivocal, “There are no colours so I make them up. Blue is for dead things, green is for sick. Pink always works for healthy stuff…I massage the whole thing to make it understandable to an audience.”

Spatial and spectral characteristics highlight the disparity between these artists and those who sought to reproduce a visually accurate account of nature such as Maria Sybilla Merian, Ferdinand Bauer, or Walter Hood Fitch. Art historian James Elkins proposes that, “as in the history of art, images of unrepresentable objects put a strain on the pictorial conventions they inherit, finally breaking them and becoming different
kinds of pictures.” (569) The graphic language of these (New World) artists at the time of burgeoning science was a distinct departure from graphical conventions and media techniques of artists who had preceded them, such as Matthaius Merian in the sixteenth century.

Anton Von Leeuwenhoek had expressed incredulity35 when he glimpsed the microscopic world in the seventeenth century. His amazement and wonder may have been similarly articulated by Drew Berry’s response to what he sees and knows of phenomenon occurring at very high resolutions.

“… a very alien world down there – a random, vibrating, messy place that’s just so interesting to portray and engaging…”

At the beginning of this chapter I quoted Stafford’s deliberation regarding the new optical instrument.

“The microscope’s mysterious and beguiling images ... explode attractive forms into repugnant or non resembling patterns. The equivocal nature of information gleaned from optical apparatus, rendering the insignificant significant and the worthwhile worthless, also reveals how easily the observer’s perception might become confused. What appeared clear and distinct to the naked eye was exposed as chaotic or flawed under the lens.” (148)

When Stafford refers to the incomprehension and confusion with which the microscopic dimensions were received by observers in the seventeenth century, it is easy to position contemporary observers at this same juncture.
I have shown how scientific imaging of plants has moved between the empirical and aesthetic. The facts of structure, process and function and the presence of artifacts that are synthesised in contemporary visualizations obscure the boundary between truth and invention, and contribute to maintaining the paradox of microscopy. Embedded in all these images made through the microscope is the measure of veracity (of the data) that places the invisible into the visible domain. The increasing scope of technology subverts inherited convention and dictates the re-imaging of nature.

With developments of photo-microscopy, spectroscopy, electron microscopy and other techniques as well as the tools of the nineteenth and twentieth century, it became possible to measure, know and visualize processes and functions of molecules and atoms further within cells to a much greater extent than these artists/scientists could actually witness. The graphic language and the vocabulary of images is radically revised in the twenty-first century in the visualization of the data produced, using these and other techniques. Spatial resolutions, spectral characteristics, and the veracity of images acquired, transmitted and archived by these instruments have become radical departures in visualizing the natural world, while building on the achievements of the early naturalists who used simple magnification devices to observe.

---

1 An artifact in an image refers to the presence of features that result from technical aberrations; in a biological specimen something that is not naturally present but has been introduced or produced during a procedure such as staining or sectioning.
1) the development of visually accurate representations of plant specimens and 2) the visual representation of theories of classification.

These lenses were designed to reduce chromatic (colour) aberration. Achromatic objectives to bring light of two different wavelengths, apochromat objectives consist of three or more elements of different types of glass designed to bring three colours to the same focal point, thus reducing its chromatic aberration. The combination of Abbe’s objectives and the method of illumination developed to optimize image quality by Professor August Köhler in the mid-nineteenth century led to the Photomicrograph. (Davidson)

http://www.brianjford.com/wbbrownb.htm

Stomata are gas openings, pores between two cells in the epidermis. They are structures formed between cells—two guard cells forming a pore in the epidermis, where as the nucleus is subcellular.

A fluid filled cavity in the cytoplasm of a cell (Collins 1597)

Emst Abbe (1840-1905) German mathematician and physicist who made several of the most important contributions to the design of lenses for optical microscopy. In partnership with Zeiss he was research director of Zeiss Optical Works 1866. For six years, Zeiss and Abbe worked intensively to lay the scientific foundations for the design and fabrication of advanced optical systems. Objective: a lens or combination of lenses in an optical instrument nearest to and facing the object being viewed.

"Parenchyma (pair-RENK-kuh-muh) are the most common type of plant cells involved in a variety of functions, such as carrying out photosynthesis, storing food and water, and providing structure." (Nabors 51); and “parenchyma: a soft plant tissue consisting of simple thin-walled cells with intervening air spaces” (Collins 1066)

A fluid filled cavity in the cytoplasm of a cell (Collins 1597)

Digital and analogue techniques applied in all areas of science for analysis of data and material phenomena.


Electron microscope co-invented in 1931 by Germans, Max Knott and Ernst Ruska

Gombrich “Mirror and Map” 1982.


Refer to “Filling Hook’s void” in this chapter 5.6 Subcellular phenomena and visualization.

In 1895 the non-optical portion of the spectrum became visible with Wilhelm Conrad Roentgen’s X-Ray, Chemistry, analogue and digital image manipulation and reproduction techniques, from photo microscopy mid-nineteenth century to Spectroscopy and other techniques.

"Includes structures that are close to the limit of resolution imposed on the light microscope by the wave properties of light”.

In her discussion of Wilhelm Conrad Roentgen’s X-Ray 1895

"...one aspect of our reading (of works of art) is based on notions of the power of representations to mirror or simulate reality itself. This is associated with the privilege of sight over the other senses in western philosophical discourses on knowledge. To see, fully and accurately, is to know; consider the enormous significance granted to seeing bodies, cells and atoms in our scientific understanding of the world. To represent the objects in the world correctly is to know and understand them. Representation is inextricably linked to the power of knowledge.” Meskimmon (4)

Crump defines the period of “post-modern science” or “Big Science” as being determined by “more than an increase in scientific knowledge. The transformation in the scale, both of the international establishment, and of the equipment and apparatus at its disposal... specifically 4 p.m., 2 December 1942 ... (when)... Enrico Fermi’s atomic pile went critical for the first time.”

The technique of making wafer thin slices of specimens for microscope slides using a microtome was first done by Purkinje.

Refer to Flannery’s discussion of the empirical and aesthetic value of three drawings of the cell in the twentieth century (Wilson, Scientific American, and Goodsell), and their value, limitations "persistence" and reuse.
meristem n. a plant tissue responsible for growth, whose cells divides and differentiate to form the tissues and organs of the plant. Meristems occur within the stem (see cambium) and leaves at the tip of the stems and roots. [C19: from Greek meristos divided from merizein to divide, from meris portion] –merisematic (adj.) Collins 924.

The transmission electron microscope produces an image of a specimen by passing a beam of electrons through it. Electromagnetic fields manipulate and focus the beam, and the magnified image can be viewed directly on a fluorescent screen or recorded by black and white photography.” (Gunning 2).

The SEM microscope bounces electrons off the surfaces of the object and “a computer that analyses the trajectories of the electrons produces the image.” Nabors 27

“Lignin is a rigid molecule that strengthens and stiffens cell walls in vascular plants; the most common polymer in plants after cellulose.” Nabors 592

“Cells may also be stained to highlight metabolic processes or differentiate between live and dead cells in a sample. Cells may be enumerated by staining cells to determine biomass in an environment of interest.” Bruckner.

Pigmentation can be assessed using other methods such as High Performance Liquid Chromatography (HPLC) but the sample is dead.

A Helium Argon laser 680 nanometres (near infra red).


Photographic manipulation has always been possible but as Mitchell states “extensive reworking of a photographic image to produce seamless transformations and combinations is technically difficult, time consuming, and outside the mainstream of photographic practice.” (7)

Or in fact heard. Drew Berry’s animation “Apoptosis” has an accompanying sound track by Franc Tetaz, who does sound design for feature films.

For Goodsell and Berry, Robertson and others artists wowing “the audience” is also significant intention and they are part of the enlightenment tradition of captivating, entralling and educating.

“I can’t wonder at it … since ‘tis difficult to comprehend such things without getting a sight of ‘em.” Van Leeuwenhoek in Nabors 28.

Other techniques, confocal microscopy, nanotechnology.
Chapter 6 Observation and Experience

Introduction

"There is no necessity to take an “anti realist” (cf. Hacking, 1983:21ff) position in order to grasp that graphic displays and other representations are not simply pictures of natural objects. Whether or not one believes in the reality of the entities and the theoretical relationships made visibly present in e.g., electron micrographs or autoradiographs of systematically prepared tissue it is possible to see that other, equiprimordial, representational orders are created and sustained through scientists’ use of such documents. Representations can represent other representations in complex socio-technical networks: the sense conveyed by a picture may derive as much from a spatio-temporal order of other representations as from its resemblance or some external object.” (5)


This chapter “Observation and Experience” examines my body of creative work Re-Imaging Nature 2002-08 and its relationship to the preceding discussion. The work includes a series of artists’ books, archival inkjet prints, and digital video projection and installation that culminated in the exhibition Re-Imaging Nature: Hidden Visions and Ground Truth, FCA Gallery, University of Wollongong NSW September 2008 (refer Figure 6.02 and 6.07). I made the objects and images that comprise this exhibition /installation during the previous seven years of research, and some of these, the prints, artists’ books and the boxed objects I exhibited separately in group and solo exhibitions and installations between 2002-07 (refer Appendix 1.)

This work is about the relationship between the concerns of my art practice and ideas and concepts of the role of images in science. I will describe the background and origin of the project and the works that anticipate the installation Re-imaging Nature, and then I will describe the exhibition /installation Re-Imaging Nature: Hidden Visions and Ground Truth 2008.
The background to this thesis is a body of work that resulted from the opportunity to assist environmental scientist Dr Toni O’Neill on field trips to Lake Mungo in western NSW in the 1980s when I was working primarily as a painter and printmaker. These are the series of archival ink jet prints in the artist book *Fruitingbodies* 2000, and the installation *Groundcover* 2000 (Introduction Figures 1a-b and 6.01a-b). The field trips were underpinned by a long running conversation between us about our own work in art and science, and our respective responses to the Lake Mungo environment. The field trips provided an opportunity to experience this site and to discuss, observe and increase my understanding of the methods used in Toni’s research.

Arriving in Lake Mungo from a dense urban setting, my initial response to its environment was to the immense scale, the vast sky, and the minimalism of the topography. By comparison to a built environment it seemed almost featureless but the combination of sky and distant sand dunes accentuated an awareness of its space. The groundcover vegetation and atmosphere were continuously transformed by fluctuating light, colour, temperature and sound. What I responded to and documented at Lake Mungo was a heightened, multi-sensory experience of being immersed in the environment, rather than the layers of phenomena that were to be seen, observed or known to be below its surface.

Our experiences of the site were governed by the specialized knowledge of our respective disciplines. This was made more noticeable when, a decade later (1997), I joined an artists’ camp at Lake Mungo. The collective awe and wonder experienced by the artists there corresponded to my own initial response there ten years earlier. The works *Fruitingbodies* and *Groundcover* 1999-2000 resulted from collaboration with Toni (University of Wollongong 1999), and in these works
her images, inscriptions and texts conflated with my own imagery and research to represent the site through the specimens. The site of Lake Mungo was central to the work.

The number and range of images, inscriptions and texts used in Toni O’Neill’s field and lab work as a biological scientist surprised me, as did their character. I was intrigued by the interplay of technology and array of instruments with which these were generated and assessed. Her fieldwork included sampling and collecting of botanical specimens, methodical accounting, measuring, calculating of groundcover of specific quadrates (groundtruthing), as well as reference to botanical field guides, electron micrographs, and remotely sensed satellite data. These assemblages of information were overlaid and cross-referenced with other objects, readings and data. What I became aware of is similar to philosopher Bruno Latour’s endorsement of the laboratory observation by sociologist Michael Lynch, “who was struck by the extraordinary obsession of scientists with papers, prints, diagrams, archives, abstracts and curves on graph paper […..] The objects are discarded or often absent from laboratories…” Bruno Latour 39-40

The work (Fruitingbodies 2000 and Groundcover 2000) was a later response to this diversity, and essentially these two exhibitions acknowledged the impact of the complexity of specialized visualizations and methods Toni O’Neill used in her research work, what Lynch (6) refers to as “rendering practices through which specimen materials are successively transformed into mathematized icons”. The richness, diversity, complexity and visuality of the images/material used to see, observe and know this site by an ecologist extended the means I had (using pencils, paints and camera) to record, document and respond to the experience.
In the two print series (the artists’ book *Fruitingbodies* 2000 and the 5 meter wall panel for the installation *Groundcover* 2000), I brought together a range of analogue and digital images being used by Toni O’Neill: botanical drawings, the Landsat (satellite image), electron micrographs, diagrams of cells, inscriptions (notes) and textual material relating to her procedure with my own watercolour paintings, pencil drawings, photographic account of the location and of plant specimens and their inscriptions (notes) collected at the site and kept in the University of Wollongong Herbarium (Figure 6.01).

In both series of prints these images were scanned into image manipulation software, and recombined using digital tools to produce electronic collages. Each of the fifteen prints in *Fruitingbodies* 2000 was based on a different watercolour wash made in the studio and a botanical illustration of a specific species studied at Lake Mungo; additional layers of imagery and text (described above) were woven into these two elements. The format of each print was consistent and the material selected for each plant subject and its manipulation created a relationship between the singular prints to form an interrelated whole work. This was presented in the three-section concertina artist’s book *Fruitingbodies* 2000. (This series of prints has been since republished in a larger format using archival inks and papers that were unavailable at the time they were originally made.)

I used the same software techniques to make the images of the 5-meter wide x 10 cm wall panel in the installation *Groundcover* 2000. In these prints the spatial characteristics of the images were used to develop a narrative that could be read at very close range, using a series of magnifying glasses. The panel from left to right changed from showing a series of magnified images of cells in electron micrographs of the selected species collected at Lake Mungo, to forms and
features of land and vegetation visible with the naked eye in the centre sections to visualizations of the site from the remotely sensed satellite data.

The context and form of these two sets of prints presented different experiences. The prints of *Fruitingbodies* were encased in a portable artist’s book that could be handheld and viewed intimately as a conventional book, or presented and displayed in the round (refer to the Introduction Figure 1a), but due to the structure of the book not all fifteen prints were able to be viewed simultaneously. In contrast to this discrete object, the 5-meter panel of prints in *Groundcover* was openly displayed as part of an installation space. The viewer entering the space was initially presented with a whole view of the floor piece and wall panel. To simulate a panorama or horizon the wall panel was positioned on the farthest wall of the gallery (from the entrance) and the viewer was required to traverse and read the length of the gallery space over a floor covered in earth coloured canvas and sand and white silk printed (with descriptions of ways that the satellite image functions in different contexts). Engaging with the floor piece and the panel of “landscapes” (the images of the prints) and reading each one (the tiny text required a magnifying lens in order for them to be read), simulated the task of groundtruthing, a process in which the scientist (O’Neill) meticulously identified and documented the ground cover of specific quadrants (sites) and compared this information to the satellite data readings of the same site.

My interest in exploring a space for specialized viewing was a continuation of my earlier practice that was informed by my training as a printmaker and painter in the late 1970s. These techniques, and the related processes of drawing and collage were central to my practice until the early 1990s. The relationship between environments and technology underpinned much of this early work, as I explored perceptions of physical spaces and the viewer’s relationship to it. Scale
and imagery were a means of placing the viewer metaphorically into these works. My practice has been characterized by shifting boundaries, opportunities to situate myself outside the studio and for periods of time to immerse myself in different contexts, from urban industrial sites in the centre of Melbourne and Sydney (1984-87) to remote natural environments, of the Antarctic Peninsula (2004) and the Highlands of Scotland (1991-2005). In my position as resident artist, through commissions and public art projects I came to know various sites, institutions and organizations, and to engage with different disciplines and specialists and explore the boundaries between these contexts. The public art project to developing a body of work for the new Remand Centre in Melbourne (1989) emphasised the issue of boundaries and the scrutinizing gaze in an extreme way. It was confronting being within the ultimate controlling institution and dealing with its culture and purpose of physical and psychological confinement and surveillance. At the centre my series of glass box constructions {
\textit{handpressure /IXL}} for the exhibition \textquoteleft The Rock Drill and Beyond \textquoteright (1998), I used the lens and the mirror as I explored the relationship between technology, observation and being, in the late twentieth century. Through these projects I have been motivated to comprehend and reconcile more fully the process of observing and of being in (position), and the nature of the boundaries between the space of my body, and experiences between technology and nature.

In the course of the research for this project \textit{Re-imaging nature} 2002-08 I have produced and exhibited hand printed and painted artist’s books, digital prints, and installation. Throughout these formats, a range of images and inscriptions have been combined and juxtaposed with textual accounts from historical and contemporary sources that arose during the research. A selection of this material is/ has been “reshuffled and recombined” (Latour 45), incorporated and synthesised in exhibition and installation spaces of \textit{Re-imaging nature: Hidden}. 

127

“Although artefacts are fairly common in day to day laboratory research, their existence does not markedly inhibit the programmatic treatment of features of graphic visibility as the sensual properties of scientific objects. There is little point in doing otherwise since the “original” objects of microscopic research, for instance, are always hidden until they are made observable through the artifices of staining, sectioning magnification and devices of graphic representation …” Lynch 180

This exhibition is about the spaces of display and the ways of knowing and conceptualizing nature within the complexity of George Seddon’s definition of nature outlined in the Introduction. The exhibition space was divided into two spaces Hidden Visions and Ground Truth (Figure 6.02, 6.07, 6.08) that were concerned with observation and experience. In this discussion I describe these two modes, observation and experience, in relation to each of the spaces, and the objects and elements presented in them. Through this work I examine the lacunae between art and science in re-imaging of nature, and the veracity of sensory experiences in contemporary visual arts practice.

Vegetation in extreme environments

The objects and images I chose to use in making this work were influenced and directed by my interest in vegetation occurring in extreme environments. The material was gathered and researched from a range of sources that included: laboratory sessions in the Biological Sciences, University of Wollongong; field trips in Australia, Scotland and Antarctica; research at the British Museum, Natural History Museum London, and The Botanics, The Library and Herbarium Royal Botanic Garden Edinburgh.
Gathering material: in the field and laboratory

At the beginning of my project Dr. Sharon Robinson, School of Biological Sciences, University of Wollongong gave me access to her research of Antarctic vegetation and her use of contemporary images, texts and inscriptions as plant eco physiologist. This was critical in that it provided me with material plant subjects that yielded images, inscriptions and data of processes and functions that occur at a sub-cellular level (such as photosynthesis). This situation enabled me to see how her methods and processes in the laboratory contributed to the meaning and value of the data and the research aims.

At the School of Biological Science, University of Wollongong, I researched how data and images were developed and specimens of Antarctic moss specimens were monitored and tested to reveal information that could be used to indicate changes in climate. Andrew Netherwood demonstrated and explained thoroughly the use of the confocal microscope on Antarctic moss specimens Ceratodon purpurea (some frozen for five years), and provided images relating to Dr. Robinson’s research of the Antarctic vegetation.

These small (and unspectacular) plant specimens are central in Dr. Robinson’s research and I was able to continue my research of them in two other ways that were critical to my project. First, with the assistance of curator Sally Rae at the Herbarium Royal Botanic Garden Edinburgh, I examined moss specimens from Polar Regions, and then accessed their documentation in The Botanics, (The Library Royal Botanic Garden Edinburgh). This made it possible to draw together (Latour), to (re) assemble the original dry specimens collected in the nineteenth century, with the images drawings print and the textual accounts4. Some of this original material I have described in Chapter 4, and I have used it in the series of
archival ink-jet prints *Digitalis, The Real Thing*, (figure 6.03a-d, 6.04a-b); in the display boxes of the space of observation *Hidden Visions* (Figure 6.05d), and in the script for the sound projection *Ground Truth* (Supplementary material Appendix 3).

Handling and observing these elaborately documented dry moss specimens (*Foreign Musci*) collected nearly 200 years ago in extreme environments seemed extraordinary. It broadened my understanding of the plant subject itself, and of botany and biological science through the research methods and processes that had spawned a plethora of images, inscriptions and texts.

My perception and appreciation of the small Antarctic moss, through the confocal microscope images; as potted live plants and as dried specimens, within the herbarium and laboratory contexts far removed from their original environment; was changed by field trips. The field trips further influenced my thinking about the ways nature is perceived, experienced and known in the spaces of science and art.

The first of these trips in 2003 was to the Sub-Antarctic Plant House (and the temperature controlled container labs) at Royal Botanic Garden, Hobart (refer to the Introduction Figure 4b). This space displayed real plants in a building where cold, moist, wind simulated the sub-Antarctic wind chill. The backdrop to the planted walkway with explanatory labels was a series of convincing tromp l’oeil scenes based on views of Macquarie Island with penguins and sea birds. The Sub-Antarctic Plant House showed off the range and extent of the vegetation that grows at this inaccessible latitude. In this space the plants could be observed altogether and inspected closely with blasts of cold air and fine spray of moisture, offering something of the sense of being in an extreme natural environment.
The following year I had the opportunity to actually be in this extreme environment when I visited the Antarctic Peninsular (at latitude similar to Dr Robinson’s own Antarctic research sites). On the ship’s landings in this overwhelmingly profound natural environment I observed the moss vegetation in a context well removed from the herbarium and the laboratory. Remote from familiar terrain and relatively vulnerable on a ship, the extreme scale of this white vast space, the abundance of animals and birds that swam and flew, the unpredictable and sometimes hostile weather conditions contributed to heighten my sense of immersion in nature, not unlike my earlier experiences at Lake Mungo. I came away preoccupied with finding ways to explore this position and its relationship to the ways that I responded to and knew nature. Similarly, another field trip to document live moss specimens on the Cairngorm, Mountain Scotland (2004) was also an important contribution to this sense. The opportunity to be in these extreme places enabled me to synthesize my vicarious knowledge of these plant subject (acquired through the range of contemporary and historical images), with an actual tangible physical sensory experience of their desolate, cold, windy, white environments.

6.02 Hidden Visions: a space of observation

“In addition to the issue of likeness, the mirror acts as a metaphor for framing images. In the aesthetic realm, as in the philosophical, the frame constructs the image or the knowledge. The frame places certain material into the centre of discourse and marginalizes others. That which is within the frame of the mirror is proper; it can be described seen and understood. That which remains outside the frame of the mirror is out of bounds disturbing and indecipherable. To move the mirror is to change the frame and thus to consider different knowledges and different subjects.” (4) Meskimmon 1996.
The first space of the exhibition *Hidden Visions* (Figure 6.02) is focused around the act of observation. I have presented an array of objects for looking and viewing: sealed display boxes arranged on plinths in the centre and around the walls, framed prints, and herbarium storage boxes, a wall of green lace material and mirrors (Figure 6.02). I placed these things to facilitate viewing the objects in them, and to resemble the space of display and observation associated with a museum or a working laboratory for “looking”; and to emphasise what curator and writer Nicholas de Oliveira (1994) described as “localized, highly specific reading” of the material placed in them (8).

The absence of explanatory labels on each item was intended to orientate the viewer to consider the whole space and the possibility of connections between the objects within it. The purpose of mirrors in this specialised space designed for seeing and examining, was also calculated to visually locate and incorporate the viewer’s presence within the contents of the display, and space of display itself.

The geometric arrangement of the central plinths in *Hidden Visions* was based on the quaternary plan of early botanical garden of the Medical School at the University of Padua (1545). An image of the garden’s map appears in the series of prints *Digitalis* 2003-06 (Figure 6.03a-d) displayed in frames on the wall and it is present in the artists’ book *Digitalis* 2002 in the display case. Access to the exhibits is limited, sealed in boxes they are untouchable and can be only inspected visually. The collection of items here: the hand made artists books, ribbons, confocal microscope cell images, faux herbarium packets, botanical drawings, magnifying lens, coloured pigments, and decorative china all do relate to each other and aspects of the ways artists, botanists and biological scientists have observed plants and visualized them within their disciplines. Their inaccessibility in
this exhibition converts them to props but also confers preciousness and an objectified reading of nature.

I used boxes as a direct reference to the framing of knowledge in specialized contexts and of seventeenth century cabinets of curiosity that had inspired Merian’s journey to Suriname to see the real things for herself (Figure 6.05a-d). In the Introduction to *Metamorphosis Insectorum Surinamensis* Merian refers to having seen some of the greatest natural history collections of the era. These included the collections of Dr. Nicholas Witsen, a board member of the East India Company; and Frederick Rysch (to whose daughter Rachel she also taught painting), and Levinus Vincent. While Merian (in Davis 167) remarks on the collections of ‘foreign’ insects and ‘marvels of nature’ in the cabinets of curiosity, and “examined with wonder the different kinds of creatures brought back from the East and West Indies”, she was also motivated by their limitations. Absent from these specimen collections and accounts of the contemporary insect books were their origins and transformations. Merian states to the reader, “So I was moved to take the long and costly journey to Suriname” (Davis 167).

The two stacks of labelled herbarium boxes each approximately 1.25 meters in height and the display boxes and their contents referred to factors that governed the status and value given to images of plant subjects in the systematic study of nature in the eighteenth and nineteenth centuries. The Herbarium boxes of taxonomy and the botanical treatise were essential in the sorting, comparing and ordering of plant subjects and images that would be able to stand for the real thing. The compartments in this display recall the layout of specimens in rectangular boxes on the respective pages of both Johann Gesner’s of Class III Triandria from *Tabulae Phytographicae* 1795-1804 (Figure 3.15); and Walter Hood Fitch’s presentation of nine bryophyte (moss) specimens in 3 x 3 rows in J D Hooker’s *Flora Antarctica* 1844 (refer Figure 4.06 Walter Hood Fitch, Plate LVII).
I chose a range of green pigments and green ribbons to include in the boxes to highlight the continuing significance of colour and spectral values for artists and scientists (Figure 6.05a). These items underline the importance of colour stability, permanence, and calibration that concerned artists seeking visually accurate colour to represent botanical subjects in watercolours and print reproducing; and the different role of spectral values in the visualisation of data in contemporary biological science.

The presence of mirrors and magnifying glasses refers to the optical aesthetic: the significance of visual accuracy in the development of specialised knowledge in botanical and biological science, and the power of representations to simulate reality. The level of visual accuracy in Merian’s illustrations contributed to the increased value of images in botany and the fact of the (specimen’s) image being an icontype (refer Chapter 3). The drawings of botanical illustrations in display boxes with magnifying glasses simulate the use of the icontype in the systematic classifying and ordering of plant specimens and the status of visual material. An icontype is a visual account of a type specimen that could be used by botanists in the herbarium that would function instead of the real thing especially where that original type specimen no longer existed (Saunders 97).

In a way my whole installation is itself a mirroring of scientific modes of representation, while including through an imaginative response, a personal relationship to the possibilities in relating to nature.

The multi coloured ribbon and decorative china refer to the unexpected relationship between the textile industry, decorative arts and the work of artist scientists (Figure 6.05b). Often tied with a decorative ribbon the plant subjects of
Maria Sibylla Merian’s (1647-1717) first books were used by embroiderers and tapestry weavers, (refer Chapter 2), while the ribbons are absent from the scientific work of *Metamorphosis* 1705; Dutch textile merchant Anton von Leeuwenhoek (1632-1723), credited with producing the first microscope initially ground his own lenses to count the threads of linen he traded; a designer of chintz fabric and a calico printer William Kilburn (1745-1818) illustrated William Curtis’ *Flora Londinensis*, similarly, Walter Hood Fitch whose works define the universal graphic language of botanical illustration in the nineteenth century, was first trained as a calico printer in Glasgow. The inclusion of dyed lace in *Hidden Visions* 2008 (Figure 6.02) also referred to the decorative textile tradition(s) and the aesthetic of viewing through (cells), the layers of seeing through the lens of a confocal microscope.

In the series of framed archival ink-jet prints *Digitalis* 1-4 (Figure 6.03) I combined observations and descriptions of plants for their use and beauty with fragments of fact and invention. The familiar and exotic, Foxglove (*Digitalis purpurea*) and Peacock Flower (*Caesalpina pulcherrima*) both have their medicinal values noted, and converge in the quaternary plan of the early botanical garden of the medical school of Padua University (1545). In the archival ink-jet prints *The Real Thing 1 and 2* (Figure 6.04a-b) I have re-contextualized the botanical herbarium specimen and its image with textual accounts. They reflect the status of visual knowledge and the role of the artist-scientist in developing a specialized view of nature as I have documented here.

Aside from their intrinsic value and meaning, within *Hidden Visions*, these things, the books and prints serve to represent the way knowledge becomes fixed and encoded in particular structures and forms.
Encroaching into the space of Hidden Visions were sounds from the second installation space Ground Truth, which included voices competing to be heard over bird calls, thunder, and a conglomeration of other natural sounds. Discussion of this follows in the next section of this chapter.

6.03 Ground Truth: immersed in sight and sound

“For almost a century, from the time Picasso and Braque added found objects to their paintings—and certainly by the time Duchamp exhibited his urinal and Bicycle wheel (circa 1915)—artists have been treating their audience to experiences that aren’t pre-eminently visual.” (Nelson 17)

The Australian critic and writer Robert Nelson8 highlighted the paradox of visual art when he declared in 2006 the “visual” in contemporary visual art “is an anachronism”. Susan Hiller’s sound installation1 Clinic 2004 at Baltic Contemporary Art in Gateshead 2004, which was sited in the white light filled warehouse space lit by the skylights and without any additional visual material exemplified his statement. In Clinic recorded voices emanated from the structural columns producing an intensely auditory-spatial experience for the “viewer”. The installation corresponded with the tradition Nelson describes, “[when] art was often part of a large architectural scheme that you experience with your feet and maybe your ears, too, as the spaces that you enter have a special acoustic. You don’t explore it with your eyes alone but with your whole body.”

The imagery in Mona Hatoum’ installation Corps étranger (Figure 2a-b) was drawn into focus by the visceral sound of a beating body. Drew Berry’s animated

---

molecular processes in *Apoptosis* 2007 (supplementary material Appendix 2 CD-ROM) were accompanied by popping, gurgling organic noises. This auditory other sense draws in; it shifts the boundary between positions of observation and experience and synthesizes the scrutiny of nature.

Walter Ong has described the dichotomy of sight and sound:

“Sight isolates, sound incorporates. Where as sight situates the observer outside what he views, sound pours into the hearer. Vision comes to a human from being from one direction at a time... When I hear however I gather sound simultaneously from every direction at once; I am at the centre of my auditory world, which envelopes me establishing me as the kind of core sensation and existence... By contrast with vision, the dissecting sense, sound is thus a unifying sense. A typical visual ideal is clarity and distinctness, a taking a part ... The auditory ideal, by contrast, is harmony, putting together.”


In science ground-truthing refers to the correlation of satellite data with what the scientist sees and measures at a specific location. In my installation Ground Truth 2008, voices recite accounts by scientists that describe particular experiences and observations in the field; specific locations are identified and listed and their voices blend with natural sounds. The meticulous detail of the descriptions (voiced here) I have transcribed from labels on specimen packets and they locate, pinpoint sites, identify, verify, and confer significance on the specimens, (refer to Figure 6.07,6.07 and Supplementary material Appendix 3 CD-ROM).

Some of these from a cupboard with the label “Foreign Musci” in the Herbarium Royal Botanic Garden Edinburgh; *The London Journal of Botany* (1844) W. Hooker;
and Merian’s voice taken from translation of *Metamorphosis 1707* and her letters. The latter brings her insect specimen to life with astonishingly detailed examination, inspecting and describing every feature. These concentrated and meticulous voices, shift, fade and break-off as they penetrate the unrelenting cacophony of natural sounds: the observing continues as they experience nature’s corporeal reality.

Three lens shaped projections Figure 6.07b and 6.08 present sites that I have visited and scrutinized in the course of this research; they include North West Scotland, the Antarctic Peninsular and Alpine regions in Australia. Each projection reveals detailed images of ground cover—rocks, mosses and grasses that tolerate extreme environments in both hemispheres. These selections are details, part of something larger that extends beyond the frame. The circular frame transforms the raw rectangular shaped framing of the image by the camera, and it confers a specific reading and a significance of the knowing eye and the lens.

This auditory assemblage of (sounds of) natural phenomena: crickets, frogs, bird calls, weather, and human voices emerge from within its space. Enveloped by the darkness within it, three lens-like circles reveal shifting glimpses of ground cover recorded at extreme altitudes and latitudes. The written accounts of scientists covering four centuries compete and converge with nature to articulate, identify and describe their location, experiences and observations in the field. *Ground Truth* is an immaterial virtual space, an aesthetic and sensory site defined by visual and auditory experience. As a visual and auditory narrative the installation seeks to transect the territory between Latour’s complicated three-dimensional experience in the field and the “optical consistency” (37) that results in the “cascade of ever more written and numbered inscriptions” of the laboratory.9
Considered together, the two spaces of Hidden Visions and Ground Truth in Re-Imaging Nature 2008 explored and reconciled my position between observing and experiencing nature, merging an artistic collage of images with a simulacrum of scientific visualizations.

6.04 Research summary

“A new visual culture redefines both what it sees, and what there is to see.” Bruno Latour 1986 “Drawing things together” (21).

In the previous chapters of “Reimaging nature” I considered the historical relationship between images and texts in both botanical and biological science. The discussion considered the purpose, value and veracity of visual material in these fields, as well as the relationship between their status and technologies used to produce them.

In Chapters 2, 4 and 5 images of cells from the seventeenth century to the present and the paradoxical nature of microscopy have been considered. Further to this, I discussed the visualization of data in biological science and the role of a range of optical technologies for observation, image generation and data visualization that have been used to comprehend functions and processes at sub cellular and molecular levels in the laboratory. These included the Robinson and Netherwood confocal microscopy (Figures 5.13) and Anne Cleary’s confocal video microscopy (Figures 5.14. and 5.15.); the representation of phenomenon and processes by artist scientists Drew Berry and David Goodsell for use in educational and other contexts (Figures 5.16 and 5.17).

This discussion highlighted the radically different nature of the graphic conventions (Latour’s “immutable mobiles”10 (26)) used in contemporary
visualizations of microscopic and remotely sensed data in comparison to those used by Merian, Ehret, Bauer and Fitch to describe images of plant subjects (Chapters 2-4). The discussion considered the dichotomy of the arbitrary nature of these new graphic elements (such as spectral and spatial characteristics, the use of multiple images, narrative, sound), alongside the veracity of data measured and generated by machines (Graetz 6). Paradoxically the inherent veracity, purpose and authority of visualizations in the laboratory or context of research, is undermined when they are removed from it. Incorrect interpretation and misunderstanding of new and sometimes arbitrary graphic language (Goodsell) such conventions as true/false colour applied to data visualisations (of microscopic samples), contributes to a blurred boundary between truth and invention and renders images ambiguous and fickle outside their original context.

Specifically in Chapters 3 and 4 the purpose and value of images was discussed with reference to their role and relationship to other data and its context (as in Bauer’s images and Brown’s textual accounts). The value of the veracity of images such as Cleary’s video microscope cell and the Robinson Netherwood confocal microscope images of photosynthesis (Chapter 5), is their relation to other data and the context of the research purpose overall, i.e. the laboratory work, other visualizations, existing and potential data. The Robinson-Netherwood and Cleary images relate to Merian’s images and textual accounts in Metamorphosis Insectorum Surinamensis (1705) where visual accuracy and context were significant for Linnaeus’ taxonomic work later in the eighteenth century.

In Chapters 3, 4 and 5 the study considered ways that the relationship (between image status, veracity and the technology was governed by different technologies such as optics (microscopy and photography); printing and
reproduction methods, and the superseding of analogue imaging techniques by
digital tools. These technologies enable visualization of biological phenomena
that occurs outside the visible spectrum, and inherent in this is a new graphic
language that interprets spectral and spatial characteristics (compared to
universal graphic language of botanical treatise Chapter 3). The consequence of
these digital computational tools revises the universal graphic language of
botany, and ways in which temporal and aural phenomena can be observed,
experienced and expressed.

Underlying/underpinning the discussion (of the role of the visual in science) is the
way in which attitudes to “nature” in Western science impose themselves on
images. Merian’s ecological approach to nature showing the relationship
between insect and plant and the temporal processes of the life cycle resemble
“stills or clips” from animation. Her approach seems to have more in common
with the liveliness of Drew Berry’s contemporary animations described in Chapter
5 [or with the Australian artist McCormack’s interactive laserdisc installation
Turbulence: An Interactive Museum of Unnatural History 1994], than numerous
images that resulted from the task of documenting and describing structures and
surfaces of botanical subjects in the intervening centuries. Artist scientists Merian
and Berry were both poised at a time of radical discovery in science and art.

The radically different graphic conventions used in visualizations of spectral and
spatial characteristics of data such as the examples discussed in Chapter 5, have
significant implications for the interpretation and readings of natural phenomena
(nature). Once these images have been removed from their original contexts (or
disconnected from the purpose and value of the laboratory research) and
placed into the wider domain (non-specific contexts used by mass media) they
become aesthetic, abstractions. A new imaging of nature is emerging that
indiscriminately absorbs these images and where science and visual imagery are part of art.

My exploration into images and the ways they are used in science has revealed unexpected ambiguities and characteristics that highlight the slippage between truth, knowledge and invention and the parameters of experience and observation in my practice. I have described earlier the origins of this project and my curiosity about the array of images used by the ecologist Toni O’Neill in observing the Lake Mungo vegetation and my awareness of the margins between our own practices. The work discussed has brought together multiple visualisations. Re-imaging Nature explores my imaginative and affective experiences of nature and the veracity of observations and representations, by the specialized context of western botany and biology. This work has resolved and reconciled dimensions of my art practice and I will continue to explore this lacuna.
1 Background to use of artists’ book form as (series).
In 1997 at the Lake Mungo artist camp Australian artist Liz Jeneid introduced me to the practice of artists’ books. Book forms offer narrative structure and provide a context for numerous possibilities for arranging material. It provided a context that allowed me to determine the way the parts of the whole series were interpreted. Further to this, the artist book form provided a solution for displaying and discretely transporting the series of 15 inkjet prints titled Fruitingbodies 1999-2000 (Figure 1a) from the UK to Australia for the touring exhibition Lake Mungo Revisited.

2 Among this work evaluating the reflectance data of C3 and C4 plants.
3 “The Rock Drill and Beyond” Inverness Museum and Art Gallery, 16 May-13 June 1998. This was a touring exhibition featuring Rock Drill (1913) by Jacob Epstein. Curated by Trevor Avery and Nigel Mullan of Another Space Ltd. Five artists were invited to respond to Epstein’s sculpture, the issue of war and technology in the twentieth century.
4 Refer Chapter 3/4 specimens described by Dr. Robert Kaye Greville, Sir J D Hooker and drawn/ printed by Walter Fitch in Hooker’s Flora Antarctica 1844.
5 This was similar to the experience of examining Maria Sibylla Merian’s folios in the British Museum and the Library at the Natural History Museum London.
6 As an artist in residence for passengers of Quark Expeditions on cruise ship MV Orlova January February 2004 Ushuaia Argentina to 56°South.
7 The garden itself is considered one of the earliest botanical university gardens, and when established in the mid-sixteenth century (1545) it was devoted to medicinal plants. Subsequently it contained exotic species from all over the world that were brought from countries that were politically or commercially connected to the Republic of Venice. The garden’s layout consists of a circle enclosed by a square divided into four quadrants, and in each are different shaped beds that when established was presented as a catalogue of known New World vegetation.
9 In his discussion of the effect of widespread literacy (of memory and written records on scientific thinking), i.e., the idea of written records being the foundation of scientific knowledge of science, Crump cites Ong on the effect of literacy [vision] on to thought processes.
10 Bruno Latour’s (26) description of immutable mobiles in Drawing things together. He explains that the process of these artist scientists - and the requirement for “optical consistency.” is that you have to invent objects which have the properties of being mobile but also immutable, presentable, readable and combinable with one another.”
Appendix 1

List of Exhibitions relating to Re-Imaging Nature Mary Rosengren 2002-2008

Individual Exhibitions

2007    Mary Rosengren–Women’s Arts International Festival, Brewery Arts Centre Kendal, Cumbria, England.
         Selected prints, Benalla Art Gallery, Victoria, Australia.
2006    Mary Rosengren prints & artists’ books, Essign Club, Owen Dixon Chambers, Melbourne, Australia.
2003    Hidden (Secret) Visions, Glass Cabinets Long Gallery, FCA, University of Wollongong, NSW, Australia.

Selected Group Exhibitions

2008    6°, Wodonga Art Space, Wodonga, Victoria, Australia.
2007    Tactics Against Fear - Creativity As Catharsis, FCA Gallery UOW, NSW, Australia.
         Wet Dry, Albury Regional Art Gallery, NSW, Australia.
2006    Pick of the Crop, Albury Regional Gallery, NSW, Australia.
2003    Poetry Science Art (2nd), Print Gallery, Dundee Contemporary Arts, Scotland.
         The 5th Street Level Open, Street Level Photoworks, Glasgow, Scotland.
         Encounters & Journeys, FCA Gallery, University of Wollongong, NSW, Australia;
         Encounters & Journeys, Craft A.C.T. Gallery, Canberra, Australia.
         Impressions: Artists Prints, An Tuierann Arts Center, Isle of Skye, Scotland.
         Departures: works in and on paper, Sturt Gallery, Mittagong, NSW, Australia.
Works Cited

Introduction


Chapter 1—Imaging Nature


1 <http://www.hsc.virginia.edu/hs-library/historical/herb/vien1.html>
2 <http://www.hsc.ohio-state.edu/hort/history/020.html>
Chapter 2 —Metamorphosis


Merian, Maria Sibylla. Der Raupen wunderbare Verwandlung und sonderbare Blumennahrung. Frankfurt am Main, Germany: n.p., 1679.


2 <http://www.hsc.ohio-state.edu/hort/history/020.html>
Chapter 3— Herbae Nudae Iconotype


Chapter 4 — Foreign Musci


Hooker, J. D. *The Botany of the Antarctic Voyage (Flora Antarctica).* London: Reeve, 1844.


**Chapter 5 —Over the Rainbow**


Chapter 6 —Observation and Experience


Bibliography


Jardine, Lisa. Interview, The Culture Show 10/02/05 BBC2 8pm.


McKay, Herbert. The Tricks of Light and Colour. London: OUP, 1947


Merian, Maria Sibylla. Der Raupen wunderbare Verwandlung und sonderbare Blumennahrung. Frankfurt am Main, Germany: n.p., 1679.

---. Etucarum ortus, a limentum et parada x metamorphosis in qua origio.papulum,transformatico, nec non tempus, loc us et proprieteseruc arum veminum, papilionum, muscarum,a lionumque, hujusmodi exanguium animal-culorum exhibentur. Amsterdam, The Netherlands: J. Oosterwyk, 1718.


Nelson, Robert. “Anachronism of visual art” *The Age* A2 Sat May 27 2006 : 17,18


Acknowledgements

I would like to thank Professor Diana Wood Conroy and Associate Professor Sharon Robinson for their continuous supervision, encouragement, and support throughout this project. Their guidance and special insights into the different areas of my research has been invaluable.

Cathy Mordant for guiding me to the moss sites in an early spring whiteout on Cairngorm Mountain, Scotland. Susan Currie of the Quark Expeditions Team for sharing her considerable knowledge and understanding of Antarctica, and for contributing to the success of my artist in residence project on the voyage South.

David Long and staff at The Botanics, the Herbarium and Library of the Royal Botanical Garden, Edinburgh, were most helpful. In particular Sally Rae who opened up the collection of Foreign Musci and whose knowledge and generous time spent over many days made it possible to connect real things with images and written accounts. Julie Harvey for guidance with preliminary research on Maria Sibylla Merian in the Entomology Library, Natural History Museum, London. Also, my appreciation to Professor Elaine Shemilt and Professor Leslie Head for their interest and perspectives on the project.

Many thanks to Brian Gilkes of Pharos Editions and Murray Robertson, Glasgow Print Studio for their expertise and care with the prints. Andrew Netherwood for his involvement and interest, and his time and assistance with the confocal microscope.

I would also like to thank my colleagues at Mount Beauty Secondary College who have been so generous with their own time and technical help. Graeme Bottomley for assistance with the projections, Cathy Gunn for her interpretation of the script and the recording, Pip Cain for mixing the sound, Jenny Farrington and Vivienne Mitchell for crucial practical support.

Very special thanks to Julia Young for many invaluable conversations and who has devoted so much of her precious time to guide me through significant stages. My sincere thanks to Liz Jeneid who introduced me to artists’ books and suggested to me the direction of a research project. Her friendship and generous hospitality made it possible for me to undertake this project from Ballachulish, Scotland and Mount Beauty, Australia.

Thank you to Hugh McNicholl for his resilience, support and love.
Re-Imaging Nature

Volume Two

Mary Rosengren
List of Illustrations

Introduction

Figure 1(a-b)
(b) Mary Rosengren, Groundcover Installation. floor: canvas, printed silk, sand, leaves, 500 x 700 cm; wall panel digital prints, magnifying glasses. 10 x 500 cm. 2000.

Figure 2(a-b)

Figure 3(a-b)
(b) Olafur Eliasson, Waterfall, College Green University of Dundee) Our Surroundings” Dundee Contemporary Arts, Dundee 14 May - 17 July 2005.

Figure 4(a-b).
Figure 4(a) William Smith’s Rotunda
Photograph Mary Rosengren 2003

Figure 4(b)
Sub-Antarctic Plant House, Royal Botanic Gardens Hobart, Tasmania.
Photograph Andrew Netherwood 2003.

Figure 5.

Chapter 1 Imaging Nature

Figure 1.01

Figure 1.02 (a-c)
(a) chaste tree (Vitex agnus-castus L.;f36v), (b) lords-and –ladies (Arum marculatum L.;f 98r), (c) opium poppy (Papaver somniferum L.;f.221v)
Figure 1.03
Dedicatory miniature to Anicia Juliana from (facsimile copy of) Codex Vindobonensis, ca. 512 AD. Constantinople. Rpt <http://www.sas.upenn.edu/~parment/juliana.html> 15/6/02 5.26pm

Figure 1.04

Figure 1.05

Figure 1.06
Dioscorides, De Materia Media from Baghdad c. 7th century. One of numerous versions; rpt Pavord, The Naming of Names: The Search for Order in the World of Plants. (London Bloomsbury, 2005) 60.

Figure 1.07 (a-b)

Figure 1.08. Printed herbal 2. Mandrake, grapevine, unidentified herb and a clover, woodcut from Le Grand Herbier (Paris before 1522); rpt Rix, The Art of Botanist. (London: Bracken, 1989) 17.

Figure 1.09

Figure 1.10

Figure 1.11
Chapter 2 Metamorphosis

Figure 2.01

Figure 2.02

Figure 2.03(a-b)

Figure 2.04

Figure 2.05

Figure 2.06

Figure 2.07

Figure 2.08

Figure 2.09

Figure 2.10
Figure 2.11
Illustration of cork cells viewed under microscope, from Robert Hooke, *Micrographia*

Chapter 3

Figure 3.01(a-d)
Meadow saxifage
3.01(a) from Manuscript Herbal of Apuleius c.1050; 3.01(b) illumination from Herbal of Apuleius 9th century; (c) woodcut (or metal cut) from Herbal of Apuleius printed edition 15th century, rpt. Blunt & Steam *Art of Botanical Illustration* (Woodridge, Eng.: Antique Collectors Club, 1994.) 37 & 56.; (d) watercolour Paul Wrigley, rpt. Field Guide to the Wild Flowers of Britain. (London: Readers Digest, 2001.) 152.

Figure 3.02

Figure 3.03

Figure 3.04

Figure 3.05(a-c)

Figure 3.06

Figure 3.07

Figure 3.08

Figure 3.09

Figure 3.10

Figure 3.11

Figure 3.12

Figure 3.13

Figure 3.14
Georg Dionysis Ehret. Fruitification of the common fig (Ficus carica), Table LXXIV, copperplate engraving from C J. Trew, Plantae Selectae, Nuremberg, (1750-92), rpt. Saunders Picturing Plants. (United Kingdom: Zwemmer, 1995) 91.

Figure 3.15

Figure 3.16

Figure 3.17

Figure 3.18

Chapter 4

Figure 4.01
Portait of Robert Kaye Greville (1794-1866), botanist c.1863 from Science and Society Picture Library 3/9/03 5: 43 pm Science Museum Pictorial.

Figure 4.02
Herbarium specimen sheet.
Figure 4.03

Figure 4.04
Herbarium specimen sheet.

Figure 4.05
Detail figure 4.04 Herbarium specimen “With coloured sketch 1824”.

Figure 4.06
Walter Hood Fitch Plate LVII. Lithograph from J.D. Hooker, The Botany of the Antarctic Voyage (Flora Antarctica). (London, Reeve Brothers, 1844.)

Figure 4.07(i-iv)
Herbarium packet, specimen, illustration and textual description. (i) Herbarium packet label “no 53 Splachnum purpurascens Lord Auckland’s Islands Antart. Exp 1839-1843 J DH”; (ii) Herbarium specimen “Spl. purpurascens J DH Herbarium RBG Edinburgh”; (iii) detail. Fig.V, S. purpurascens Plate LVII. Walter Fitch, from Flora Antarctica; (iv) “in moist bogs” a textual description of Splachnum purpurascens from J. D. Hooker, The Botany of the Antarctic Voyage (Flora Antarctica). (London, Reeve Brothers, 1844.)

Figure 4.08
Walter Hood Fitch: Sphagnum
detail of Plate LVII. Fig. VI. Sphagnum, lithograph, from J.D. Hooker, The Botany of the Antarctic Voyage (Flora Antarctica). (London, Reeve Brothers, 1844.)

Chapter 5

Figure 5.01
Robert Brown’s microscope from Linnean society from Brian Ford Brownian Movement <http://www.brianford.com/wbbrownb.htm>

Figure 5.02
Cells seen through microscope of Robert Brown 1827
The view of about twenty Orchid epidermal cells under Brown’s microscope showing the nucleus within each cell and three stromata. From Brian Ford’s 1992 reconstruction of Robert Brown’s observation of Brownian movement through his microscope in 1827.

Figure 5.03

Figure 5.04
Bunji Tagawa drawing of eukaryotic animal cell.
Figure 5.05
Cell sections diagram.
Diagram 1. "Fig. 1". The appearance of objects after ultra-thin sectioning and formation of a projected image, from Gunning, Brian E. S. and Steer, Martin W. Ultrastructure and the biology of plant cells. (London: Edward Arnold, 1975.) 8.

Figure 5.06
Cell diagram
Diagram 2. Fig. 2, Diagram of an undifferentiated cell, from Gunning, Brian E. S. and Steer, Martin W. Ultrastructure and the biology of plant cells. (London: Edward Arnold, 1975.) 11.

Figure 5.07
Light Microscope image
Plate 1 The Plant Cell (1) from Gunning, Brian E. S. and Steer, Martin W. Ultrastructure and the biology of plant cells. (London: Edward Arnold, 1975.) 185.

Figure 5.08
Transmission Electron Micrograph

Figure 5.09
Transmission Electron Micrograph
Detail Figure 5.08 (above) Plate 3, The Plant Cell (3) from Gunning, Brian E. S. and Steer, Martin W. Ultrastructure and the biology of plant cells. (London: Edward Arnold, 1975.) 189.

Figure 5.10
Scanning Electron Micrographs of pollen.

Figure 5.11
Combination of Transmission Electron Micrograph and Scanning Electron Micrograph

Figure 5.12 (a-c)
(a) Light Micrograph showing natural colour of the plant cells rpt. Nabors Murray W. Introduction to Botany. San Francisco (CA: Pearson, 2004) 27;
(c) Scanning electron micrograph where colour has been applied to the image after scanning. rpt. Nabors, Murray W. Introduction to Botany. SanFrancisco (CA: Pearson, 2004) 27.
Figure 5.13
Confocal microscope
(a) Ceratodon purpureus Confocal microscope image sets 1-4 Andrew Netherwood 2003 Biological Science Lab, University of Wollongong;
(b) Apparatus of confocal microscopy laboratory: the specimen slide Ceratodon purpureus;
confocal microscope and Andrew Netherwood 2003 UOW; monitor images/software; Faculty of Biological Science UOW. Photograph M. Rosengren, 2003

Figure 5.14
Confocal video microscopy stills Anne Cleary.

Figure 5.15

Figure 5.16
Drew Berry, digital animation stills
Animation DNA sequence unravelling. Stills from of Quick Time Movies Chromosome _Coil.mov; DNA_CU.mov; DNA_mov; from Drew Berry WEHI 2006

Figure 5.17(i-ii)
Goodsell David
(i) Black and White Drawing

(ii) Watercolour painting
A cross-section through an Escherichia coli bacterial cell shows the location of large molecules rpt. Goodsell David S, Scripps Research Institute <http://mgl.scripps.edu/people/goodsell/gallery/patterson.html>

Chapter 6

Figure 6.01(a-b)
Mary Rosengren
(a) Fan Saltbush Atriplex angulata. Archival ink jet prints 43 x 58 cm, from the artist book and print series Fruitingbodies 2000.
(b) Grey copperburr Bassia diacantha Archival ink jet prints 43 x 58 cm, from the artist book and print series Fruitingbodies 2000.

Figure 6.02
Mary Rosengren
Re-Imaging Nature: Hidden Visions 2008,
FCA Gallery, University of Wollongong September 2008.
Installation in-situ showing display boxes on plinths, framed prints, artist book boxes, stacked herbarium boxes. Foreground display boxes contain mirrors, faux herbarium packets, confocal microscope prints of moss specimen Ceratodon purpureus. Others various: mirrors and multi-coloured ribbons, broken decorative china, powder pigments, botanical drawings and lenses.
Figure 6.03 (a-d)
Mary Rosengren
(a) Digitalis 1 2003 Archival digital inkjet print.
(b) Digitalis purpurea (foxglove) 2006 Archival digital inkjet print.
(c) Digitalis–Caesalpinia pulcherrima 2006 Archival digital inkjet print.
(d) Digitalis–(sphagnum) moss cells 2006 Archival digital inkjet print.

Figure 6.04 (a-b)
Mary Rosengren
(a-) The Real Thing 1—Caesalpinia Pulcherrima (Peacock Flower), 2003. Archival ink-jet print, 20 x 100cm.
(b) The Real Thing 2—Bryum 49°S, 2006. Archival ink-jet print, 20 x 100cm.

Figure 6.05 (a-d)
Mary Rosengren
Hidden Visions detail wooden display boxes 30 x 30 cm
(a) Green ribbons; powder pigment; mirror.
(b) Multi coloured ribbons; decorative china; mirror
(c) B/W pen drawings x 3, from bulb-bloom; lens x 3; mirror.
(d) Faux herbarium specimen packets, confocal microscope images Andrew Netherwood (2005), groundcover photos; illustration moss cells from Rod Seppelt, Moss Flora of Macquarie Island (2004) 10 x 10cm; mirror.

Figure 6.06
Mary Rosengren
Re-ImagingNature: Hidden Visions
Detail from display boxes (shown above), faux herbarium specimen packet labels for Ceratodon purpurea. Ink-jet print each 10 x 10cm

Figure 6.07 (a-b)
Mary Rosengren 2008
(b) Re-ImagingNature: Ground Truth 2008, DV floor projections 90 x 90 cm. FCA Gallery, University of Wollongong NSW. September 2008.

Figure 6.08
Mary Rosengren 2008

APPENDIX 2—Supplementary material CD-ROM 1

APPENDIX 3—Supplementary material CD-ROM 2
Rosengren, Mary. Ground Truth, Audio file, 3 sound tracks 2’28 CD-ROM. Voices: Cathy Gunn, Hugh McNicholl; Recording (voices) Cathy Gunn; Sound mix Pip Cain, 2008.
Figure 1(a)
Mary Rosengren. Fruitingbodies 2000
Artist’s book 15 digital prints archival paper.
29.5 x 22.5 x 4 cm folded.

Figure 1(b)
Mary Rosengren. Groundcover 2000
Installation FCA Gallery, University of Wollongong November 2000
Floor: canvas, printed silk, sand, leaves, 500 x 700 cm
Wall panel: digital prints, 4 magnifying glasses, 10 x 500 cm. wall panel.
Figure 2(a)
Mona Hatoum, *Corps étranger*
Installation projection view
Tate Britain Duveen Galleries,
"The Entire World as a Foreign Land",
Friday 24 March – Sunday 9 July 2000;
1994 video 350 x 300 x 300 cm

Figure 2(b)
Mona Hatoum, *Corps étranger*
Video projection still
Tate Britain Duveen Galleries,
"The Entire World as a Foreign Land",
Friday 24 March – Sunday 9 July 2000;
1994 video 350 x 300 x 300 cm
Figure 3(a).
Olafur Eliasson The Weather Project.
Installation view
Tate Modern Turbine Hall, London
6 October 2003 - 21 March 2004
Photograph Andrew Netherwood

Figure 3 (b)
Olafur Eliasson Waterfall,
College Green University of Dundee,
“Our Surroundings”
Dundee Contemporary Arts,
14 May - 17 July 2005
Figure 4(a)
The Rotunda Museum of Geology 1828-29 Scarborough, Yorkshire England

The dome space of the Rotunda displayed William Smith’s fossil and rock collection in cabinets above arranged around the wall of the dome above head height and below the samples a faded frieze illustrating the strata of the coastal rocks painted by his nephew. The Rotunda was the location for meetings of the Scarborough Philosophical Society of the 1820s. It is regarded as one of the earliest purpose built museums in Britain (pre-dated by Sir John Soane’s Dulwich Picture Gallery London 1817), it and has recently undergone extensive restoration. Photograph Mary Rosengren 2003

Figure 4(b)
Sub-Antarctic Plant House, Royal Botanic Gardens Hobart, Tasmania.

The display of samples of Sub-Antarctic plants is labelled and informative, the display of live plants presented against a back-drop of a tromp l’oeil scenes of sub-Antarctic island landscape. The temperature in the Plant House corresponds with the latitude of Macquarie Island. Intermittently the vents at one side send blasts of cold air and moisture through the space that simulates the changeable weather and atmosphere. Photograph Andrew Netherwood 2003
Figure 5
Diagram of optical scales

from Murray Nabors Introduction to Botany
Figure 1.01
Figure 1.02 (a-c)
(a) chaste tree (Vitex agnus-castus L.; f.36v),
(b) lords-and-ladies (Arum maculatum L.; f.98r)
(c) opium poppy (Papaver somniferum L.; f.221v)

Illuminated version of the writings of Dioscorides known as Codex Aniciane Julianae; Codex Constantinopolitanus; Codex C or Codex Byzantinus; Codex Vindobonensis or Vienna Dioscorides; ca. 512 AD. Constantinople, rpt. Lack, Garden Eden: masterpieces of botanical illustration. (London: Taschen, 2001) 25-29.
Figure 1.03
Dedicatory miniature to Anicia Juliana from (facsimile copy of) Codex Vindobonensis, ca. 512 AD. Constantinople.
Figure 1.05

Figure 1.06

Dioscorides, *De Materia Media* from Baghdad c. 7th century.

One of numerous versions;

rpt Pavord, *The Naming of Names: The Search for Order in the World of Plants,*

Figure 1.07(a) Printed herbal 1.
Woodcut illustrations from Latin Herbarius 1484,
printed by Peter Schoeffer in Mainz.

Figure 1.07(b)
Left: Printed Herbal "Narcissus" woodcut from Ortus Sanitatis (1491),
right: "Maneypeepia Upsilonia" Edward Lear from his Nonsense Botany (1871)

rpt Blunt, Wilfrid & Stearn, William T. The Art of Botanical Illustration.

Figure 1.08
Printed herbal 2.
Mandrake, grapevine, unidentified herb and a clover, woodcut from Le Grand Herbier (Paris before 1522);

Figure 1.09
Hans Weinditz (d. ca 1536) Woodcut, Comfrey (Symphytum officinale)
for Otto Blumfel’s Herbarum Vivae Eicones (1530);
rpt Saunders, Picturing Plants;
An Analytical History of Botanical Illustration 23.
Figure 1.10
Figure 1.11
Illuminated Manuscript 2.
Calendar page for March, Book of Hours, Ghent-Bruges, 1520-1530.
rpt. Kaufmann, The mastery of nature: aspects of art, science
and humanism in the Renaissance.
Figure 2.01
Jacob Marrell (1614-1681)
Wicker basket of flowers with a frog and insects.
Bodycolour and watercolour on vellum, 1634
rpt. David Scrase, Flower Drawings Fitzwilliam Museum
Figure 2.02
Abraham Mignon (1640-1679)
Blumenstück (1670) 90 x 68 cm.
Figure 2.03(a-b)
Georg Hoefnagel
Cherries, Flowers and Butterfly, 1594-96
(Scribe, Georg Bocskay, Mira Calligraphiae Monumenta).
Figure 2.04
Maria Sibylla Merian. (1647-1717).
from Neus Blumen Buch.
rpt. Rice Voyages of Discovery.
Figure 2.05
Matthaeus Merian. (1593-1650)
New World Landscape 1630
Engraving from Johann Theodor de Bry, Les grands voyages,
part XIV, 55 (Hanau 1630).
rpt Dickenson Drawn from Life: Science and Art in the Portrayal of the New World,
(London: University of Toronto Press, 1998) 42.
Figure 2.06
Maria Sibylla Merian.
Branch of Palsade tree.
Bodycolour and watercolour on vellum, 357 x 285mm, Surinam sketchbook.
rpt. Morton, A Souvenir Album of Flowers from the Royal Collection.
(London: H.M. The Queen, 1990), 35.
Maria Sibylla Merian.

Peacock Flower.

Bodycolour and watercolour on vellum. 357 x 285mm, Surinam sketchbook.

rpt. Morton, A Souvenir Album of Flowers from the Royal Collection.
Figure 2.08  
Maria Sibylla Merian.  
**Ripe Anas.**  
Figure 2.09
Maria Sibylla Merian.

Figure 2.10

Maria Sibylla Merian.

Vine branch and black grapes, with moth caterpillar and chrysalis of gaudy sphinx.

Engraving and watercolour on paper, 300 x 360 mm, Metamorphosis Insectorum Surinamensium.

Figure 2.11
Robert Hooke
Figure 3.01(a-d)
Meadow Saxifrage (Saxifraga granulata).

Figure 3.01(a) and (b) very different copies derived from the same source (from a Roman prototype Blunt 36).
In (a) the roots have been interpreted by the copyist in (b) as flowers and inverted. 
Figure 3.01(c) shows a woodcut based on this incorrect copy (b); 
(d) shows a twenty-first century field guide illustration of the same subject.

(a) From Manuscript Herbal of Apuleius, earliest known copy about 700 AD (c. 1050. British Museum) 
(b) Illumination from the Herbal of Apuleius, ninth century manuscript. 
(c) Woodcut from the Herbal of Apuleius first printed edition “Rome, 1481?” (Blunt 56). 
(d) Illustration detail by Paul Wrigley from Field Guide to Wild Flowers of Britain, London: Readers Digest, 2001) 152.

Figure 3.02
(United Kingdom: Zwemmer, 1995.) 21.
Figure 3.03
Solomon’s seal, woodcut from Pier Andrea Mattioli, Commentarii in Sex Libros Peducii Dioscoridis, Frankfurt, 1598 edition, rpt Saunders Picturing Plants. (United Kingdom: Zwemmer, 1995) 32

Figure 3.04
a) Engraving from Dodart, Mémoires (1701);
(b) Mandrake's forked root the male and female form,
Woodcut from Ortus Sanitatis, 1497, above and 1511 below,
rpt. Blunt & Stearn Art of Botanical illustration
(Woodridge, Eng.: Antique Collectors Club 1994) 58
(c) Mandrake from Le Grand Herbier
(Paris before 1522),
rpt. Rix Art of Botanical Illustration:
Figure 3.06
Chamomile (*Chamaemelum nobile*),
woodcut from *Ortus Sanitatis*,
Strasburg (c.1500),
rpt. Saunders *Picturing Plants*,
(United Kingdom: Zwemmer, 1995) 18.

Figure 3.07
Peony (*Paeonia mascula*),
woodcut from *Ortus Sanitatis*,
Strasburg (c.1500),
rpt. Saunders *Picturing Plants*,
(United Kingdom: Zwemmer, 1995) 18.
Figure 3.08

Figure 3.09
Figure 3.10
Figure 3.11
Albrecht Meyer, Crocus, woodcut from Leonhardt Fuchs, *De Historia Stirpium*.

Figure 3.12
Figure 3.13
Georg Dionysis Ehret.
Table of 24 sexual practices of plants,
copperplate engraving from
Carolus Linnaeus *Systema naturae,*
Georg Dionysis Ehret.
Fruitification of the common fig (*Ficus carica*), Table LXXIV,
copperplate engraving from C.J. Trew,
*Plantae Selectae*, Nuremberg, (1750-92),
rpt. Saunders *Picturing Plants*,
(United Kingdom: Zwemmer, 1995) 91.
Figure 3.15
Johann Gesner.
Class III. *Triadria*,
engraving coloured by hand,
from *Tabulæ Phytographicae* (1795-1804)
rpt. Saunders Picturing Plants.
(United Kingdom: Zwemmer, 1995) 151.
Figure 3.16
Georg Dionysis Ehret.
American Turk’s-cap lily (*Lilium superbum*)
watercolour and bodycolour on vellum,
a copperplate version is published
in Trews’ *Plantae Selectae* (1750-93),
rpt. Saunders *Picturing Plants*.
(United Kingdom: Zwemmer, 1995) 87.
Figure 3.17
Stella Ross Craig.
Dog Violet (Viola canina),
line block print from Volume IV Drawings of British Plants (1948-73),
rpt. Saunders Picturing Plants.
(United Kingdom: Zwemmer, 1995) 137.
Figure 3.18
Ferdinand Bauer. 
Grevillea Banksii, copperplate engraving 
Figure 4.01
Portrait of Dr. Robert Kaye Greville (1794-1866), Botanist, illustrator artist social reformer c.1863
Science Museum Pictorial
from Science and Society Picture Library 3/9/03 5:43 pm
Figure 4.02
Herbarium specimen sheet.
Moss specimen with pencil and watercolour sketch.
Herbarium Royal Botanical Garden Edinburgh.
Photograph Andrew Netherwood February 2004
Figure 4.04
Herbarium specimen sheet. "With coloured sketch 1824"
Robert K. Greville Moss specimen,
drawing of magnified detail partly finished pencil and watercolour sketch.

Figure 4.05
Detail of Figure 4.04
"With coloured sketch 1824"
Herbarium RBG Edinburgh, Photograph M. Rosengren, 2003
Figure 4.06
Walter Hood Fitch
Plate LVII. Lithograph
from J.D. Hooker, The Botany of the Antarctic Voyage (Flora Antarctica).
(London, Reeve Brothers, 1844.)
Figure 4.07 (i-iv)

Herbarium packet label, moss specimen, illustration and textual description.

(i) Label "no 53 Splachnum purpurascens Lord Auckland’s Islands Antart. Exp 1839-1843 JDH";
(ii) Herbarium specimen "Spl. purpurascens JDH Herbarium RBG Edinburgh;
(iii) Walter Fitch, Flora Antarctica detail. Plate LVII. Fig.V, S. purpurascens;
(iv) "in moist bogs" a textual description of Splachnum purpurascens from J.D. Hooker, The Botany of the Antarctic Voyage (Flora Antarctica). (London, Reeve Brothers, 1844.)
Figure 4.08

Walter Hood Fitch,
Detail of Plate LVII, Fig. VI, Sphagnum, lithograph,
from J.D. Hooker, The Botany of the Antarctic Voyage (Flora Antarctica).
(London, Reeve Brothers, 1844.)
Figure 5.01
Robert Brown's microscope
Linnean society
from Ford <http://www.brianford.com/wbbrownb.htm>

Figure 5.02
Brian Ford’s 1992 reconstruction of cells Robert Brown could see through his microscope in 1827. The view of about twenty Orchid epidermal cells under Brown’s microscope show the nucleus within each cell and three stromata. Stomata are structures composed of cells. Two guard cells forming a pore in the epidermis whereas nucleus is subcellular.
Figure 5.03
1920s Cell diagram
Edmund Beecher Wilson
from Flannery, Maura C.
"Images of the Cell in Twentieth-Century Art and Science",
Figure 5.04
Drawing eukaryotic animal cell
Bunji Tagawa
Scientific American 1961
Cell Drawing from Flannery, Maura C.
"Images of the Cell in Twentieth-Century Art and Science".
Figure 5.05
Cell sections
Diagram 1. Fig. 1.
The appearance of objects after ultra-thin sectioning and formation of a projected image.

rpt from Gunning, Brian E. S. and Steer, Martin W. Ultrastructure and the biology of plant cells.

Figure 5.06
Diagram of an undifferentiated cell

rpt. Diagram 2. Fig. 2.
Gunning Brian E. S.
and Steer, Martin W.
Ultrastructure and the biology of plant cells.
(London: Edward Arnold, 1975.) 11
Figure 5.07
Light Microscope image

Plate 1 The Plant Cell (1) from Gunning, Brian E. S. and Steer, Martin W. *Ultrastructure and the biology of plant cells.* (London: Edward Arnold, 1975.) 185.
Figure 5.08
Transmission Electron Micrograph Plate 2, Plant Cell (2)
rpt. Gunning, Brian E. S. and Steer, Martin W.
Ultrastructure and the biology of plant cells.

Figure 5.09
Transmission Electron Micrograph detail of Figure 5.08 (Plate 2, Plant Cell)
Plate 3, The Plant Cell (3) rpt. Gunning and Steer (189)
Figure 5.10 (i-ii) Scanning Electron Micrographs pollen.

Figure 5.10 (i) Plate 12 Pollen Grains (2):
The Mature Wall
rpt. Gunning, Brian E. S. and Steer, Martin W.
_Ultrastructure and the biology of plant cells._
(London: Edward Arnold, 1975.) 207.

Figure 5.10 (ii) Scanning electron micrograph of pollen
rpt. Nabors, Murray W._Introduction to Botany._
Plate 6 Xylem (2): Mature Xylem and Xylem Parenchyma

Plate showing a combination of images resulting from both Transmission Electron Microscope and Scanning Electron Microscope

Plate 6 Xylem (2): Mature Xylem and Xylem Parenchyma

Gunning, Brian E. S. and Steer, Martin W.

_Ultrastructure and the biology of plant cells._

5.12(a) Light micrograph natural colour of cell material

5.12(b) Light micrograph cells stained pink-red show lignin.

Figure 5.12 (c) Scanning electron micrograph where this colour has been applied to the image after scanning.
Confocal microscopy allows for spatial optical sectioning, viewing through layers (rather than physical sectioning which destroys the specimen), allowing for processes and functions such as occurring within the living cell to be observed. In this example, chlorophyll fluorescence of chloroplasts indicates levels of photosynthesis.
Figure 5.13(b)
The apparatus of confocal microscopy laboratory: specimen on slide; confocal microscope and monitor /software images from Faculty of Biological Science UOW. Photograph M. Rosengren, 2003
Figure 5.14
Confocal video microscopy stills
Figure 2. The build up of actin between the subsidiary mother cell's (SMC) nucleus and the adjacent guard mother cell (GMC).

Figure 3. The actin depleted zone.

Figure 5.15
Figure 5.16
Drew Berry
Digital Animation Stills DNA sequence unravelling.
Drew Berry CD WEHI, CD-ROM 2006

Digital animation
Animation Stills from Quick Time Movies
Chromosome _Coil.mov; DNA_CU.mov; DNA_mov;
from Drew Berry WEHI 2006
Figure 5.17 (i)
David Goodsell
Black and White Drawing
Simulated cross-section of
bacterium Escherichia coli
drawn at the magnification of
one million times 

rpt. A Look Inside the Living
Cell Flannery
Maura C. “Images of the Cell
in Twentieth-Century Art and

Figure 5.17 (ii)
Watercolour painting David Goodsell
A cross-section through an Escherichia coli bacterial cell
shows the location of large molecules.

rpt. Goodsell David S, Scripps Research Institute
<http://mgl.scripps.edu/people/goodsell/gallery/patterson.html>
Figure 6.01(a)
Mary Rosengren
Fan Saltbush *Atriplex angulata*
Archival inkjet prints 43 x 58 cm
from the artist book series *Fruitingbodies 2000*
Figure 6.01(b)
Mary Rosengren
Grey copperburr Bassia diacantha
Archival ink jet print 43 x 58 cm
from the artist book series Fruitingbodies 2000

Figure 6.08
Mary Rosengren
Reimaging Nature: Ground Truth 2008
Projection stills, 8:15 DV loop.
Installation in-situ showing display boxes on plinths, framed prints, artist book boxes, stacked herbarium boxes. Foreground display boxes contain mirrors, faux herbarium packets, confocal microscope prints of moss specimen *Ceratodon purpurea*. Others various: mirrors and multi-coloured ribbons, broken decorative china, powder pigments, botanical drawings and lenses.
Figure 6.03 (a)
Mary Rosengren
*Digitalis 1*, 2003
Archival inkjet print
25 x 36 cm
Figure 6.03 (b)
Mary Rosengren
(b) Digitalis—purpurea (foxglove) 2006
Archival inkjet print
36x 36 cm
Let us unsack the globe, let us with the greatest accuracy inspect every part thereof, pluck out the innermost secrets of any of the creatures, let us examine them with our gauges. ... Pry into them with all our microscopes and most exquisite instruments, till we find them to bear testimony to their infinite workman.
William Derham 1712
Figure 6.03 (d)
Mary Rosengren 2006
(d) Digitalis–(sphagnum) moss cells
Archival inkjet print
36 x 36 cm.
Figure 6.05(a-b)
Mary Rosengren 2008
*Hidden Visions*, detail wooden display boxes
30 x 30 cm each
(a) green ribbons; powder pigment; mirror.
(b) multi coloured ribbons; decorative china; mirror.
Figure 6.05(c-d)
Mary Rosengren 2008
Hidden Visions, detail wooden display boxes
30 x 30 cm each

(c) BW pen drawings x 3, from bulb-bloom; lens x 3; mirror.
(d) Faux herbarium specimen packets, confocal microscope images
Andrew Netherwood (2005), groundcover photos; illustration moss
cells from Rod Seppelt Moss Flora of Macquarie Island (2004)
10 x 10 cm; mirror.
Figure 6.06
Mary Rosengren
Re-imaging Nature: Hidden Visions
Detail from display boxes (shown above), faux herbarium specimen packet labels for *Ceratodon purpurea*
Ink-jet print each 10 x 10 cm
Figure 6.07(a)
Mary Rosengren 2008
Re-Imaging Nature: Ground Truth
Installation three audio loops and three DV floor projections.
FCA Gallery, University of Wollongong NSW.
September 2008.
Figure 6.07(b)
Mary Rosengren 2008
Re-Imaging Nature: Ground Truth
3 x DV floor projections 90 x 90 cm
FCA Gallery, University of Wollongong NSW.
September 2008.
Figure 6.08
Mary Rosengren
Reimaging Nature: Ground Truth 2008
Projection stills, 8:15 DV loop.
(a-) The Real Thing 1—*Caesalpinia pulcherrima* (Peacock Flower)
Archival ink-jet print 20 x 100cm

*Caesalpinia pulcherrima*, flower, leaf, seed pod specimens and labels from the collection Herbarium Royal Botanic Garden Edinburgh and Royal Poinciana collected Darwin; drawing of Maria Sibylla Merian’s “Peacock Flower”, folio British Museum quote from Maria Sibylla Merian’s *Metamorphosis Insectorum Surinamensium* 1705
Figure 6.04 (a-b)
Mary Rosengren

(b) The Real Thing 2—Bryum 49°S
Archival ink-jet print image size 20 x 100cm

Bryum moss specimens from collection
Herbarium Royal Botanic Garden Edinburgh 2004-2005; images and text quoted from Walter Hood Fitch J.D Hooker Flora Antarctica (1844); b/w line drawings and text quoted from Rod Seppelt, The Moss Flora of Macquarie Island 2004