Chapter 17

Archetypes: Dürer's Rhino and the Recycling of Images

17.1 Introduction: Aref's Rule

Rule-of-Thumb 5 (Aref's Rule) *Never publish the same graph more than once.*

As we shall below, recycling images has been common practice for centuries. Hassan Aref, who is professor of mechanical engineering and chief scientist at the National Center for Supercomputing Applications at the University of Illinois, is clearly no fan of this practice. Why, then, has it continued?

The first answer is that scientists are often lazy. The examples below show that often the price for this laziness is that errors in the original image are repeated over and over in its copies. Furthermore, the copies often degrade the accuracy of the original through a combination of poor reproduction, poor captions, and inappropriate, half-understood use of the image.

The second answer is that it is silly to try to make a new graph when a visual masterpiece already exists, and says the same thing better. A brilliant visualization deserves to be reproduced.

Aref's Rule is sound advice that should only be followed sometimes. In this chapter, we shall to try illustrate when recycling of previously published images is good, and also when and how it can go disastrously wrong. We begin with a few important definitions.

Definition 24 (Archetype: Dictionary) *An original form, model or pattern; a prototype.*

From the Greek $\alpha\rho\chi\iota$- *"first" or "chief", now used to mean "original" via* $\tau\upsilon\pi\tau\epsilon\iota\nu$, *"strike", combined as* $\alpha\rho\chi\epsilon\tau\upsilon\pi o\sigma$, *"first-molded".*

Definition 25 (Graphical Archetype) *A* GRAPHICAL ARCHETYPE *is a picture which is widely copied, often with retouching or a change of medium, in later editions and publications. Graphical artists sometimes simply call it a "type" for short.*

Definition 26 (Graphical Lineage) *A graphical archetype plus its copies.*

17.2 Lineages

A culture of cancer cells, removed from a woman who died of ovarian cancer in 1953, became of great importance to cancer research. The reason is that these cells, called the

"HeLa lineage", were unique in that they could flourish in the laboratory dish. (Ironically, most cancer cells, so virulent and unstoppable in the human body, perish rapidly without reproducing when transferred to a test-tube.) For thirty years, the HeLa lineage was distributed widely so that new cancer therapies could be tried upon it. Unfortunately, it was shown in the late 1980's that the HeLa culture was the result of contamination and contained no cancer cells at all.

Bibliographic lineages exist, too. Britz(1998) has amusingly documented the many citations of a 1950 paper on numerical analysis by O'Brien, Hyman and Kaplan. A year later, Leutert wrote a follow-up article and incorrectly listed the year of O'Brien *et al.* as 1951. Most later authors, apparently reading Leutert's paper in lieu of the original, repeated his error. Britz showed that of 107 citations of O'Brien *et al.*(1950), 82 list the year incorrectly as 1951. Three papers incorrectly assigned Leutert's paper to 1952.

Graphical lineages also exist. The good news is: a really good visualization can have a life far beyond its original publication as it is reprinted again and again. The bad news is two-fold. First, errors and poor design decisions can be reproduced endlessly, too. Second, the availability of a reprintable graphic can stifle thinking. Recycling a previously-published diagram may be the easy way, but it may not be the best way.

17.3 Archetypes

An example will clarify the concept of a graphical archetype. Robert E. Lee, who was arguably the greatest general in American history, was photographed only twice before the start of the Civil War in which he became famous. His 1845 daguerrotype with his son Rooney was a private family picture which was never published until after Lee's death in 1870. The other photograph, which was taken by Matthew Brady in the period 1850-1852, was used for a "carte de visite". These were similar to modern business cards except that they were used primarily for social purposes (to be given to the maid or butler when making a social call) and they were printed with not only the name of the visitor, but also, after the development of photography, with a picture. Thus, a large number of people had copies of Lee's "carte de visite". When the Civil War began in 1861, this image was the only publicly available picture of Lee.

As a result, this picture was copied and recopied. Fig. 17.1 shows the Brady original and ten copies. Some of the copies are steel engravings, others are wood engravings. In some, Lee faces to the right; in others, the image is reversed. Some show Lee in civilian clothes, as originally photographed, but many show him in military uniform. Some depict him from the waist up as he was photographed; others show only his face. Some are square-framed; others crop the image to fit in an oval. Yet the ten pictures are all just copies of a single archetype, the Brady photo. Some of the engravings are actually copies of a steel engraving by an artist named A. H. Ritchie so that these pictures are copies-of-a-copy.

The irony with this oft-copied image is that it was a fraud. Not in the sense that the Brady photo was of someone other than Lee, but rather in the sense that Lee's physical appearance had greatly changed from that depicted in all these images. At the start of the Civil War, he became too busy to shave, and grew the shaggy white beard that he wore for the remainder of his life. By 1861, his dark hair had also turned white. He never wore the dark-blue U. S. Army uniform after the start of the war, but only the grey coat of the Confederate States of America.

One can hardly blame the long-dead artists for the defects of their pictures. Only one photograph of Lee was publicly available. As the most important military figure in America, newspapers and books about the war had to have his image, even a bad one. Unfortunately, this endless copying of an archetypical image — errors and all — happens in science and engineering, too, and with much less excuse.

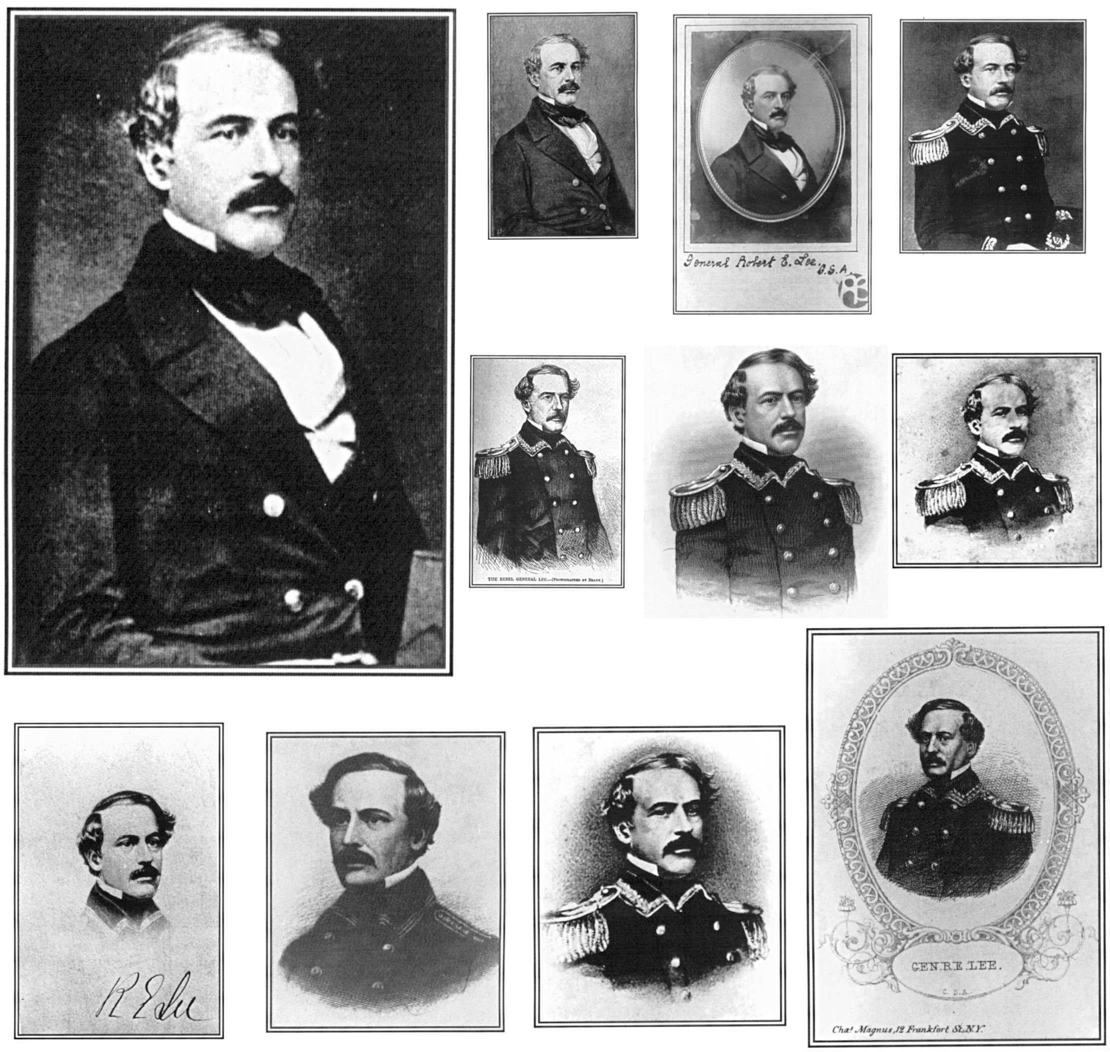

Figure 17.1: Matthew Brady in 1850-1852, is the large picture in the upper left corner. Because this was used for Lee's "carte de visite" [visiting card], most of Lee's friends had a copy. This one picture became the basis for all ten of the other images seen here.

17.4 Graphical Lineages of the Renaissance

17.4.1 Dürer's Rhino

Albrecht Dürer (1471-1528) is one of the giants of world art. Like Leonardo da Vinci, he was an intensely curious man. Where Leonardo invented, Dürer observed. Although he became wealthy and famous for his engravings, his interest in biology was quite literally the death of him; journeying far from his native Nuremberg to see a stranded whale, he came down with a fever from which he never fully recovered.

In 1515, he drew a rhinocerous. Unable to see the beast himself, he based his drawing on a sketch and a verbal description. It is remarkably accurate for a drawing-not-from-life. However, it does contain an error: a small second horn set on the shoulder.

His drawing was the archetype for a long graphical lineage. Indeed, Clarke (1986) is an entire volume of over 200 pages devoted to cataloguing all the plagiarisms of Dürer's image. The copies of Dürer are easily recognized because they repeat his mistake of the phantom second horn. Fig. 17.2 shows both the original drawing and a copy-of-a-copy.

The science essayist David Quammen in *Boilerplate Rhino* has partially rehabilitated Dürer: it is now thought that rhino observed by the artist's friend was an unusual species, and Dürer's drawing is actually more accurate than had been previously thought.

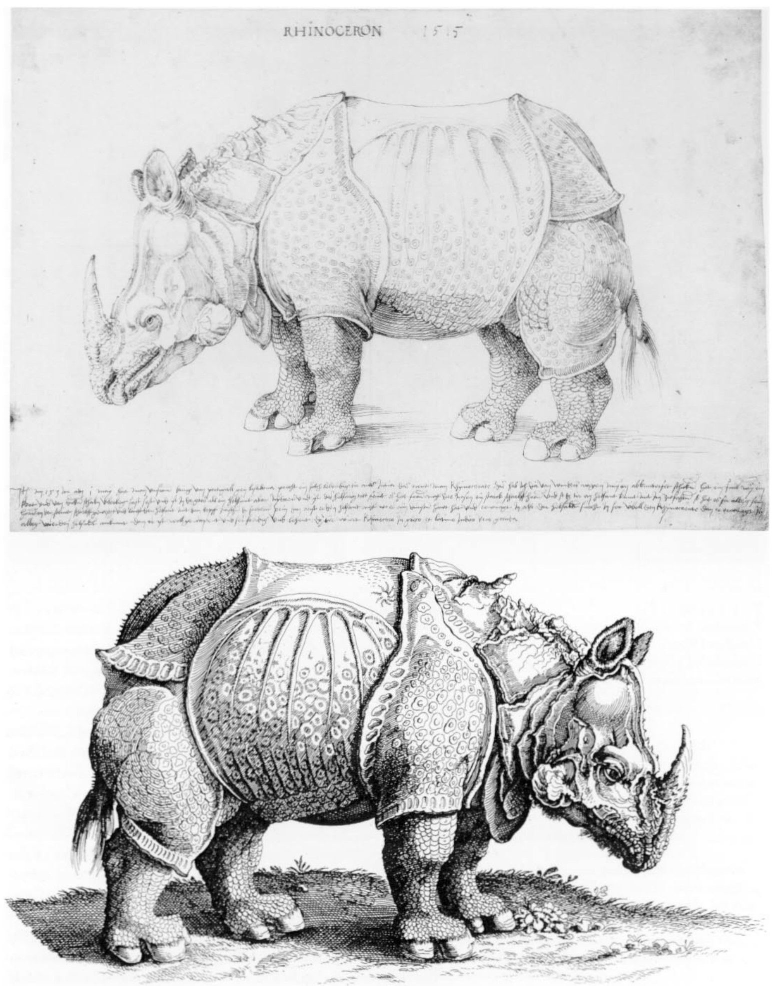

Figure 17.2: Top: Dürer's rhinoceros. He never saw the real animal, but based his diagram upon sketches and descriptions of eyewitnesses. Note that there is a small spurious second horn high on the back. Bottom: a copy of Dürer's picture, published by Johnston (1657) which is copied from Gesner (1560).

17.4.2 Hooke's Snowflakes

Robert Hooke, the brilliant demonstrator for the Royal Society in the late 1600's, was both plagiarist and plagiaree, graphically speaking. In his work on snowflakes, he accurately observed some images from nature, but apparently plagiarized other images from an earlier work by Thomas Bartholin (Fig. 17.3).

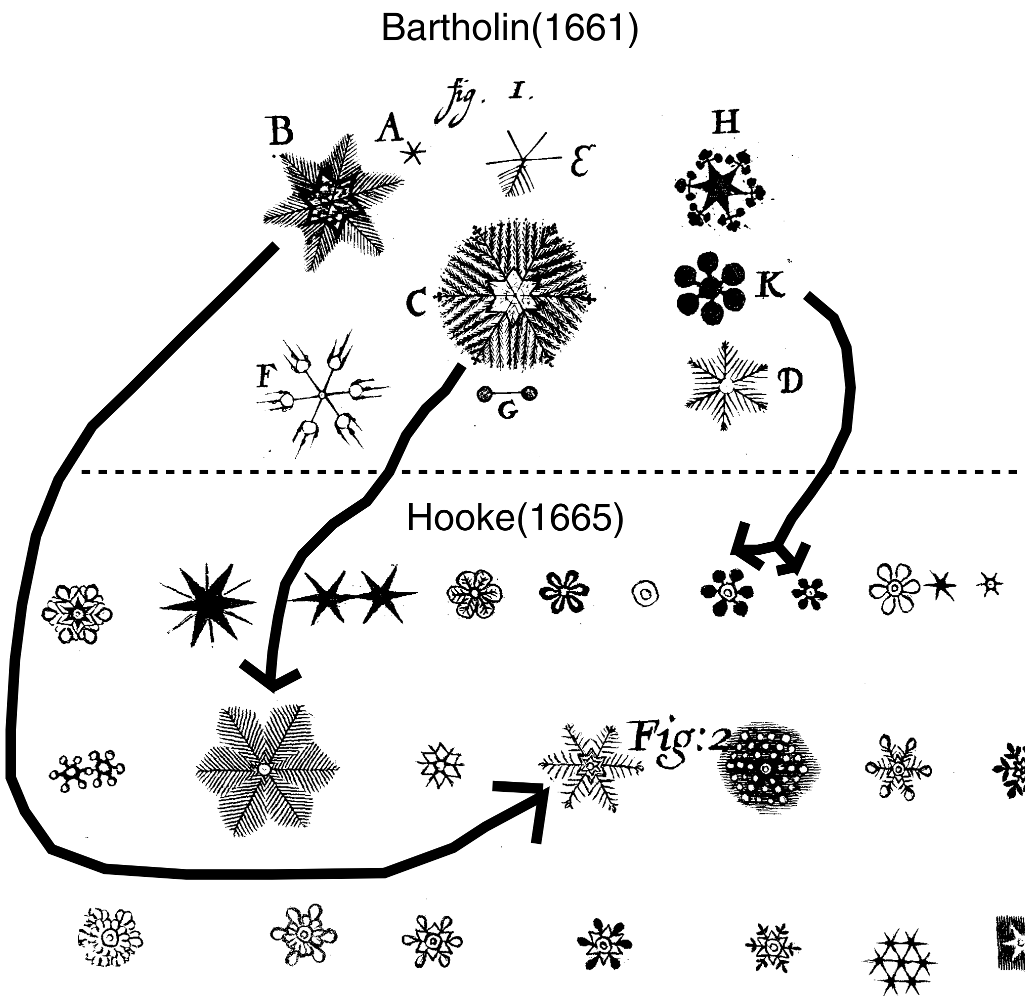

Figure 17.3:
Ford (1993, pg. 170) attributes three of the lower images, published in Robert Hooke's *Micrographia* to plagiarism from Thomas Bartholin's (1661) work, as indicated by the arrows. Top: a figure from Bartholin. Bottom: Hooke's visual catalog of snowflake shapes.

In spite of his unattributed “borrowing”, Hooke really was a superb observer. Like many of the great scientists of earlier centuries, he was a very gifted draftsman — “to draw is to understand”, one might say of the seventeenth century. His sketch of a mite was widely plagiarized by later authors (Fig. 17.4). No one gave a more accurate or detailed picture of a mite until the advent of microphotography.

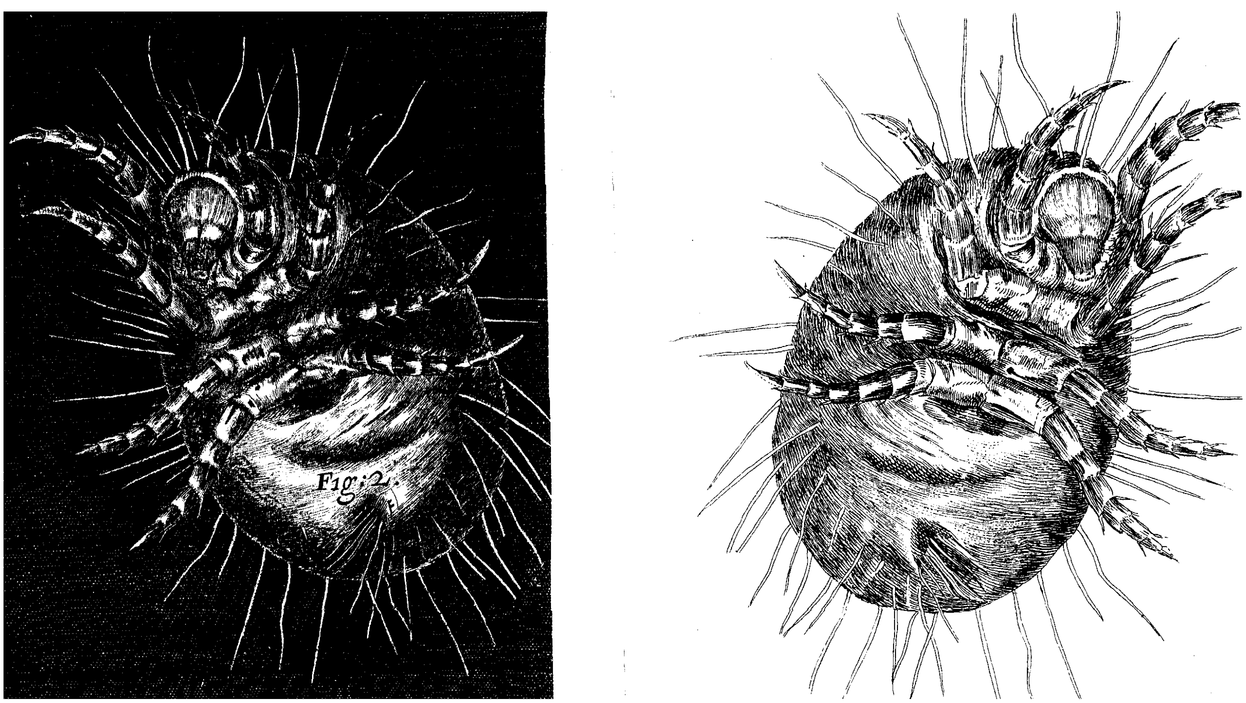

Figure 17.4: Hookes original work was widely plagiarized. The left graph is superb picture of a mite, drawn by Hooke while looking through a simple microscope. The unattributed figure on the right is from Eleazar Albin’s *Natural History of English Insects* (1720).

17.4.3 The Isle of California

A 1622 map of North America incorrectly depicted California as an island. This mistake was repeated 182 times, as late as 1745. One of these many erroneous repetitions is shown as Fig. 17.5.

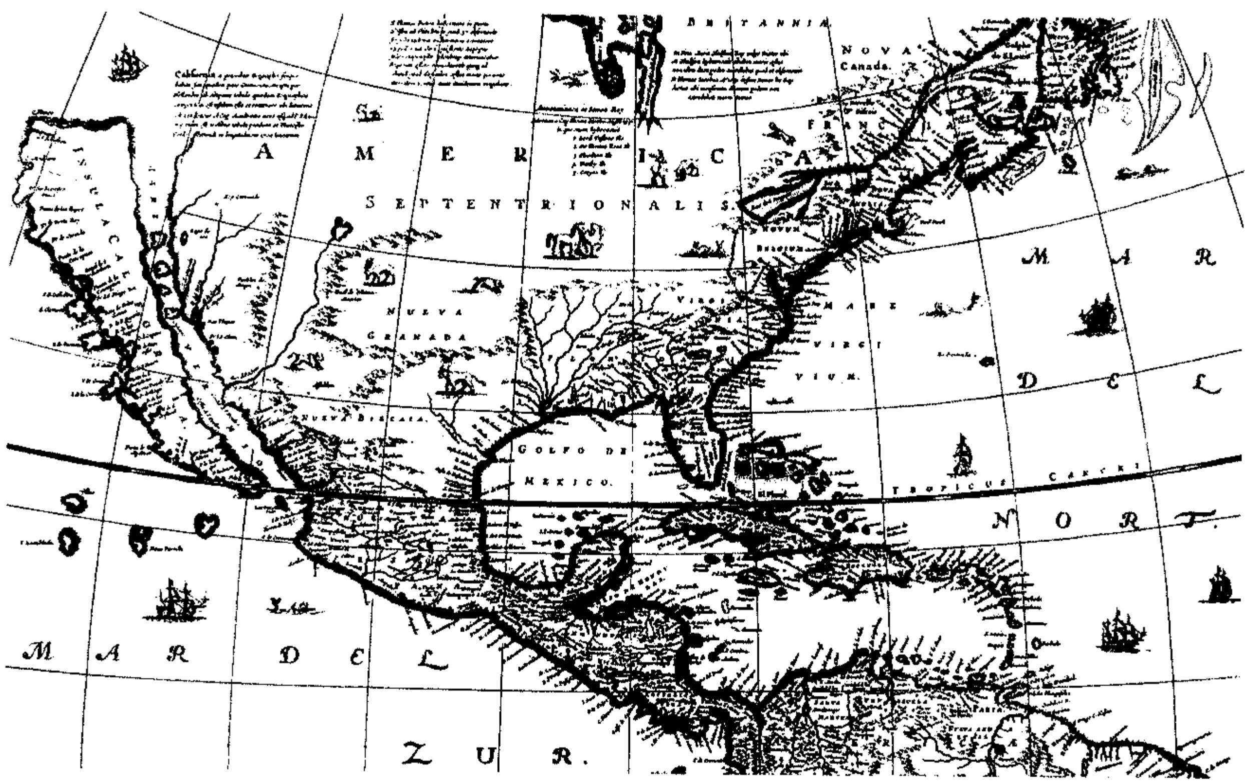

Figure 17.5: This map of 1638 shows California as a giant island. In reality, the Gulf of California, although long and narrow as depicted, does not extend far enough to cut the peninsula now known as "Baja California" from the mainland. Joannes Janssonius, *America Eptentrionales*, (Amsterdam, 1638), copying a map of 1622.

17.5 Poincaré's Pear

The shape of a rotating, self-gravitating mass of liquid has been the subject of active research for a couple of centuries. Not only is this the shape of stars, but also of solid bodies like the earth. Our planet is so large that if its shape deviated more than a fraction of a percent from that allowed to a same-sized mass of liquid, then gravity would crumble the mountains and make the stone flow as a very viscous fluid until the shape returned to the equilibrium shape.

One remarkable fact is that as the rotation rate increases, the obvious shape, which is an ellipsoid of revolution, is no longer the only possible shape or even the stable shape. Instead, there is a branching or "bifurcation" in which a triaxial ellipsoidal with three unequal axes becomes the stable shape. At higher rotation rates, still more complex shapes are possible.

One topic of intense interest: if the earth was born as a rapidly spinning mass, it might have become unstable and fissioned into the earth-moon system. The only way to test this hypothesis was to trace the different branches of equilibrium shapes. Bernard Riemann, Henri Poincaré and Sir George Darwin (son of Charles Darwin) were among the nineteenth century luminaries who pursued the figures-of-equilibrium problem.

One advantage that scientists enjoyed a century ago was that instruction in drawing was an integral part of education. (In modern America, students receive "art" instruction at all levels from kindergarden through junior high school, but most receive no art instruction in high school.) For Henri Poincaré, the drawback was that to pass his school exams and continue to college, he had to gain a passing score in drawing as well as history, literature and mathematics.

A person who can write or draw with both hands is usually called "ambidextrous", meaning loosely "both-like-right-hand". Poincaré could wield a pen with either hand, but it would perhaps be more accurate to label him as "ambisinistral". He was totally incapable of producing a recognizable drawing with either hand. His school instructors passed him anyway, though he should have received a failing grade, because his other work was so brilliant.

In 1885, Poincaré made one of his most influential discoveries: at a certain nondimensional rotation rate, the Jacobi triaxial ellipsoids bifurcated to a branch of unsymmetrical figures

Unfortunately, Poincaré translated his formulas into a cross-sectional drawing (Fig. 17.6). His illustration bulged unsymmetrically like a pear, so his new branch became known as "Poincaré's pear-shaped figure of equilibrium". This caught the astrophysical imagination so much that a new term was coined for this family of shapes: "piriform", which means "pear-shaped" in Latin.

Poincaré showed that more complicated shapes would bifurcate at other parameter values. He conjectured, "that the bifurcation of the pear-shaped body leads onward stably and continuously to a planet attended by a satellite, the bifurcation into the fourth zonal harmonic probably leads unstably to a planet with a satellite on each side, that into the fifth harmonics to a planet with two satellites on one and one on the other and so on". Sir George Darwin went on to conjecture himself that the pear-shaped figure eventually fissioned into two at a sufficiently high rotation rate, thus generating double stars and the Earth-Moon double planet.

Chandrasekhar (1969) takes up the story: "The grand mental panorama that was thus created was so intoxicating that those who followed Poincaré were not to recover from its pursuit. In any event, Darwin, Liapounoff, and Jeans spent years of effort towards the substantiation of these conjectures; and so single-minded was the pursuit[1]

[1] For example, the question of whether along the Dedekind sequence a neutral point occurs similar to

that one did not even linger to investigate the stability of the Maclaurin spheroids and the Jacobi ellipsoids from a direct analysis of normal modes. Finally, in 1924 Cartan established that the Jacobi ellipsoid becomes unstable at its first point of bifurcation ... And at this point the subject went quietly into a coma." (pgs. 11-12).

One moral of this story: don't become intoxicated with your own cleverness. Good graphics cannot redeem bad thinking.

In this case, however, bad graphics seem to have contributed to the intoxication. Although Poincaré's image was likely engraved by a professional artist, the engraver worked from a preliminary sketch by Poincaré, yes, the same ambisinistral lad who nearly flunked out of school because he *couldn't* draw.

Sir George Darwin redrew the piriform figures twenty years later (Fig. 17.7). As he dryly remarked, "Comparison with M. Poincaré's sketch shows that the figure is considerably longer than he supposed."

Why did the error matter? Poincaré's crime of visualization greatly exaggerated the bulge, and therefore implied that the piriform shape was much closer to fission than it actually was. The bad graph helped to fuel the delusion of double star and double planet theories.

the one along the congruent Jacobian sequence does not appear to have been considered or even raised.

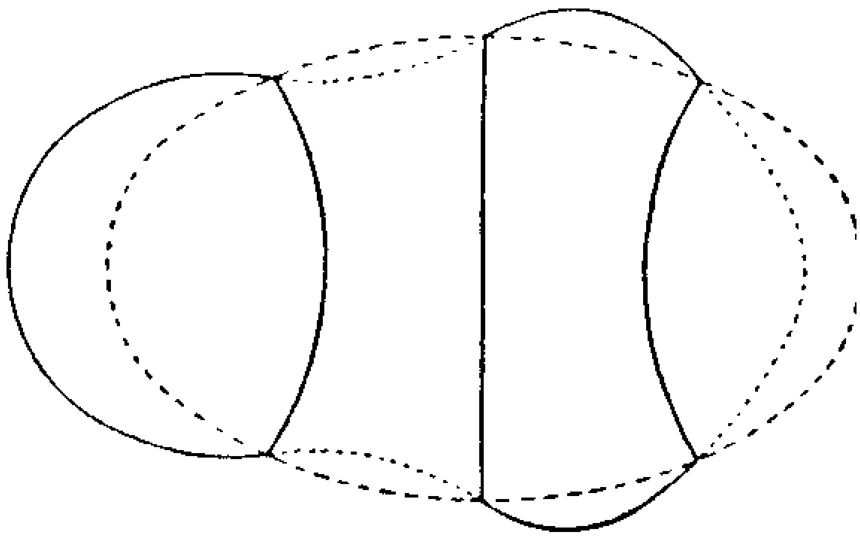

Figure 17.6: Dashed curve: Jacobi ellipsoid. Solid/dotted curve: cross-section through the pear-shaped figure of equilibrium as drawn by Poincaré, “Figures d'Equilibre”, pg. 161, and reproduced in Lyttleton (1953), pg. 110.

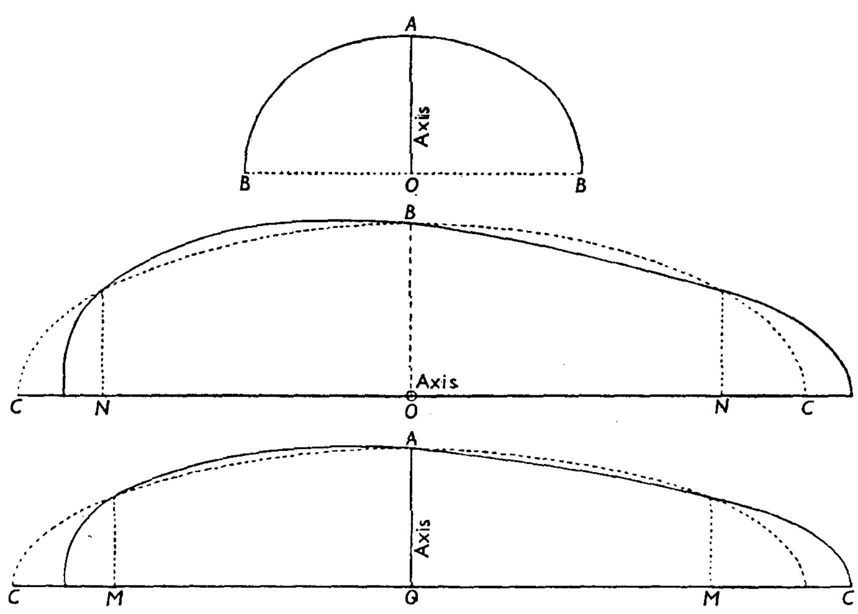

Figure 17.7: Solid curves: the Jacobian triaxial ellipsoid at the bifurcation as seen in three different cross-sections, each through two of the three axes of the ellipsoid. Dotted curve: the pear-shaped figure that is also a figure of equilibrium at this set of parameter values. From Sir G. Darwin, *Scientific Papers*, vol. III, pg. 314.

17.6 Equatorial Waves

In the oceanic phenomenon known as El Nino and the atmospheric phenomenon known as the Southern Oscillation, which are a coupled air-sea quasi-periodic motion known as "ENSO", so-called "equatorial waves" play a special role. These are planetary scale waves which are confined to low latitudes because of the refractive effects of the earth's rotation. They occur in both the atmosphere and the ocean and were discovered in the early 1960's. The earliest meteorological paper to give a general classification scheme with analytical solutions for these waves was by Taroh Matsuno in 1965. This discovery was so important that it is being honored with a special conference in Honolulu to celebrate the 1/3 of a century anniversary of his work!

One of the reasons that Matsuno's paper had a great impact was that it contained good diagrams — so good that some of them have been recycled almost as endlessly as the Matthew Brady *carte de visite* of Robert E. Lee.

17.6.1 Horizontal Plane

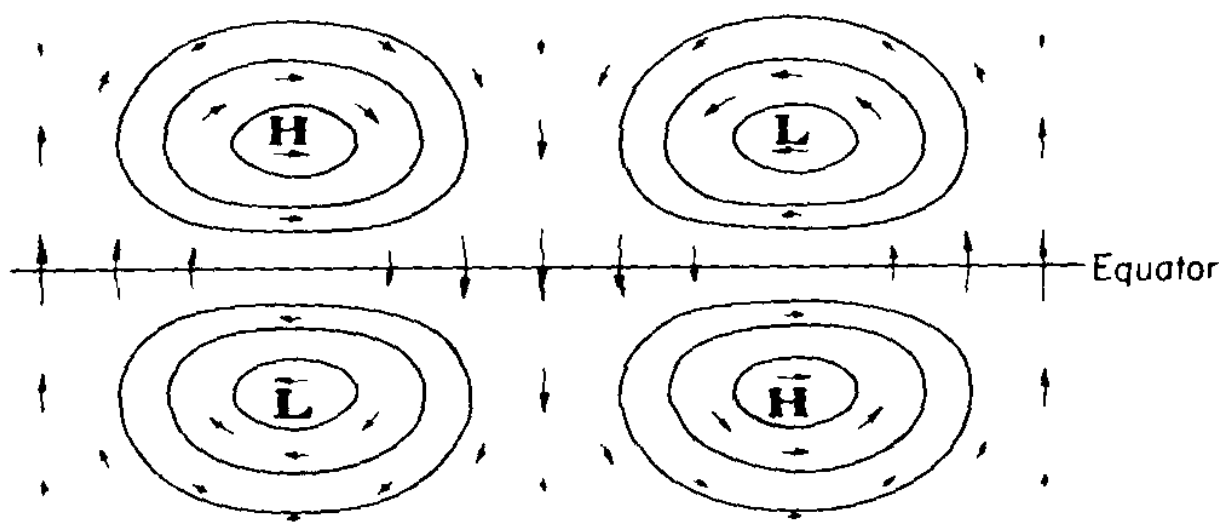

Figure 17.8: Horizontal velocity (arrows) and pressure (contours) for the equatorially-trapped Yanai wave. This image was first published by T. Matsuno in 1966. It appeared again in a review by J. M. Wallace in 1973, in J. R. Holton's 1975 monograph on the middle atmosphere, in the later middle atmosphere book by Andrews, Leovy and Leovy (1987), in all three editions of Holton's *Introduction to Dynamic Meteorology* and in the second edition of Pedlosky's *Geophysical Fluid Dynamics*.

Adrian Gill's *Atmosphere/Ocean Dynamics* is the only book or review in the last thirty years that has discussed equatorial waves but not recycled Matsuno's diagram. This is a very good book in part because Gill resisting the temptation to copy blindly. He not only drew his own schematic for the Kelvin and mixed-Rossby gravity waves (Fig. 17.9), but also provides many novel analyses and illustrations which have no counterparts in other texts on geophysical fluid dynamics.

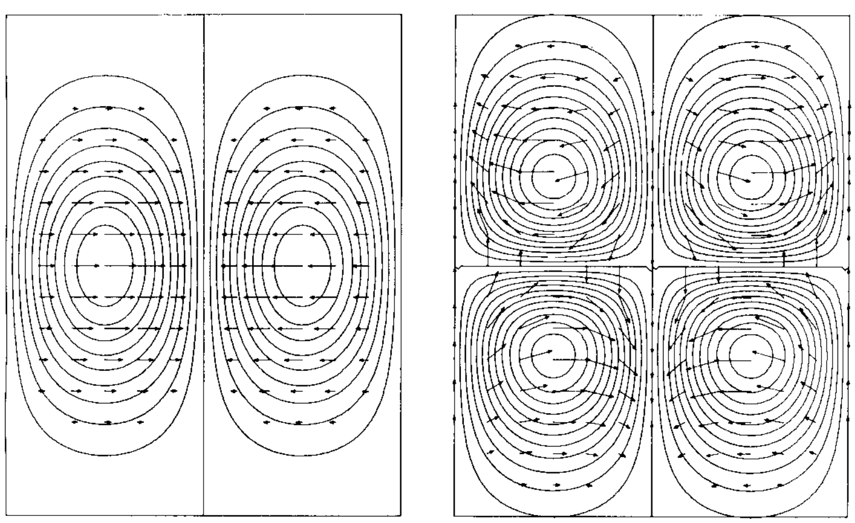

Figure 17.9: Resisting an archetype. Adrian Gill's *Atmosphere-Ocean Dynamics* did not recycle Matsuno's schematic diagram, but instead evaluated the analytical solution to make his own diagram. Left: Kelvin wave. Right: Yanai wave.

17.6.2 Vertical Cross-Section

"A good scientist is one who knows enough to steal from the best people."
— James R. Holton

Another archetype for equatorial waves is the vertical cross-section for each wave species. These simultaneously show pressure, temperature and all three velocity components through a mixture of shading, arrows, word-labels, and out-of-the-plane head/tail arrows. Because this diagram is complicated, and would require a considerable investment to duplicate, this figure has been recycled numerous times.

Once again, Adrian Gill was the exception, preferring to draw his own figure. Unfortunately, his illustration is not as complete as the archetype.

There are two conflicting precepts. One is that it is good to be original instead of slavishly copying prior visualizations. The other is that if a graph is really good, with carefully organized complexity, it may be very difficult to improve upon it, or even to do as well. The wise visualizer is pragmatic: sometimes a plagiarist, sometimes an innovator.

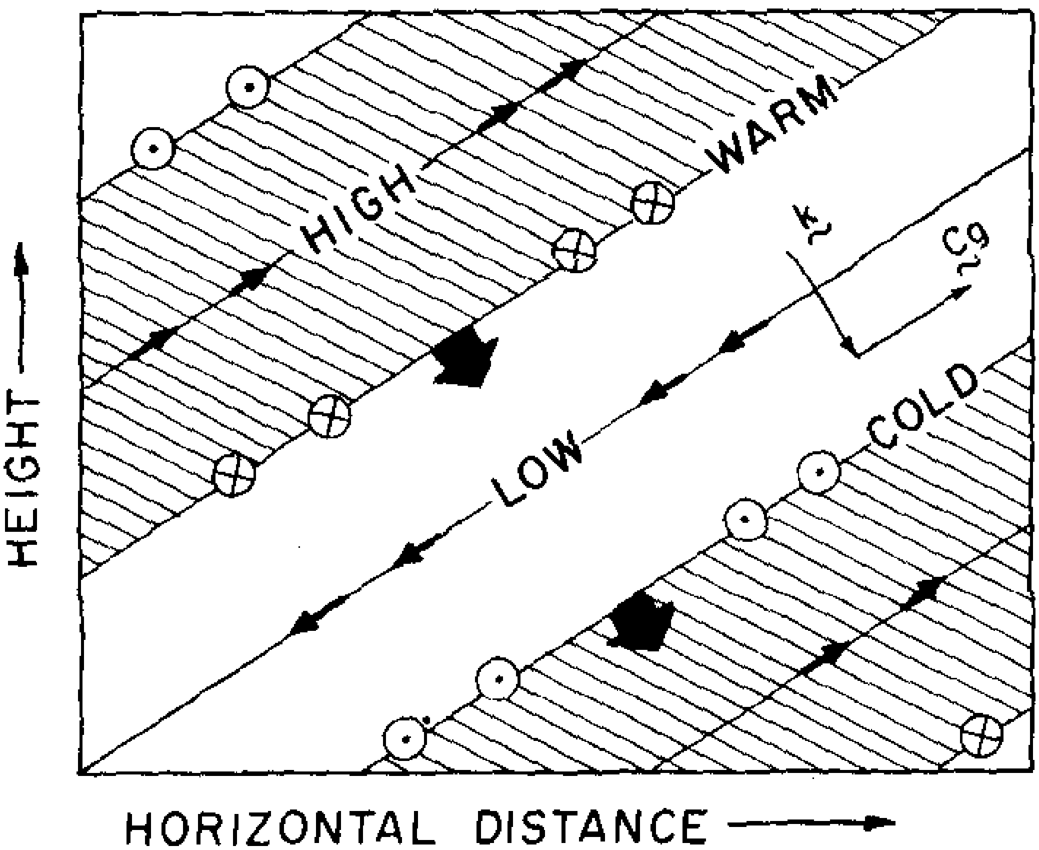

Figure 17.10: A vertical cross-section through a Yanai wave. The labels “High” and “Low” mark the lines of maximum and minimum pressure. The arrows show the direction of the eastward and vertical velocities. The disks-with-central dot and the disks-with-x’s mark the nose and tail of arrows indicating the north-south velocity, which is out of or into the plane of the paper. (The vertical scale has been greatly exaggerated; in the real world, the horizontal scale is a couple of orders of magnitude larger than the vertical scale.) This diagram has appeared in Holton’s *Introduction to Dynamic Meteorology* and a wide variety of other sources.

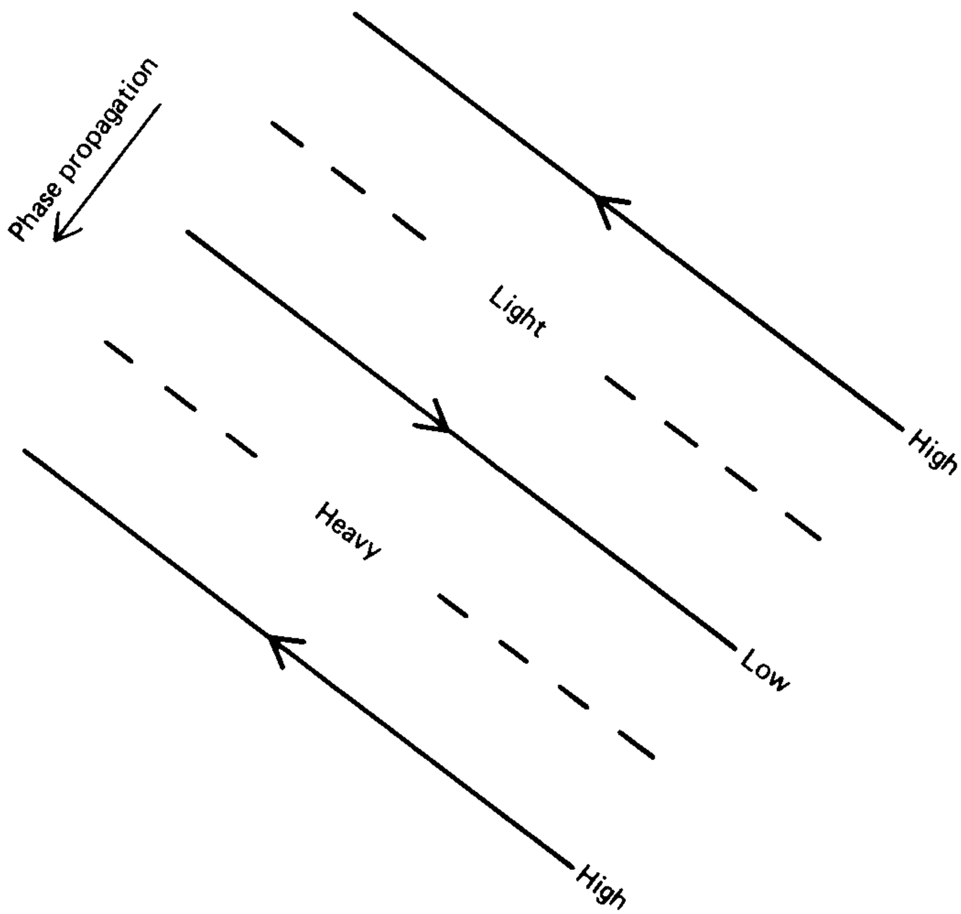

Figure 17.11: Resisting an archetype. Adrian Gill's *Atmosphere-Ocean Dynamics* did not copy the vertical cross-section diagram of Holton's book, but drew his own.

17.7 A Good Archetype

The drawing below was originally made for the undergraduate textbook by Wallace and Hobbs(1977). It was reprinted in Holton (1992). This was probably a prudent decision.

First, in accord with the quote from Holton given earlier, the diagram "steals from the best people": J. M. Wallace has also been elected to the National Academy of Sciences and P. Hobbs is a very distinguished cloud physicist.

Second, the diagram is a SCHEMATIC, a conceptualization. It would be very difficult to reproduce this with graphing software; it needs to be DRAWN (or redrawn) by a professional artist using an illustration program.

Third, the diagram is graphically intricate. Four different vertical levels are stacked in perspective. The bottom layer schematically shows the contients and oceans. The second and fourth layers are superimposed contour and quiver plots showing the horizontal flow and pressure. The third layer is a series of columns with arrows and labels "hot" and "cold" to depict the vertical circulation and the temperature of the air being carried up and down. One suspects that Wallace and Hobbs labored over their preliminary sketches to get it just right, and the professional artist labored too to combine all these elements into a clear illustration.

Fourth, the diagram illustrates an important phenomenon in a clear way. To put it another way, if you recycle, reprint only the good stuff.

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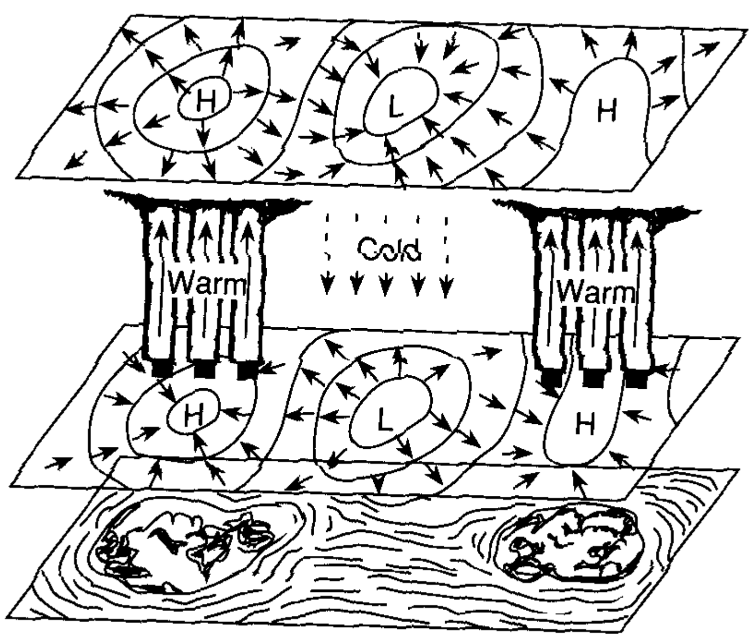

Figure 17.12: Summer monsoon circulation. First published in Wallace and Hobbs (1977); reprinted in the third edition of Holton (1992), pg. 379.