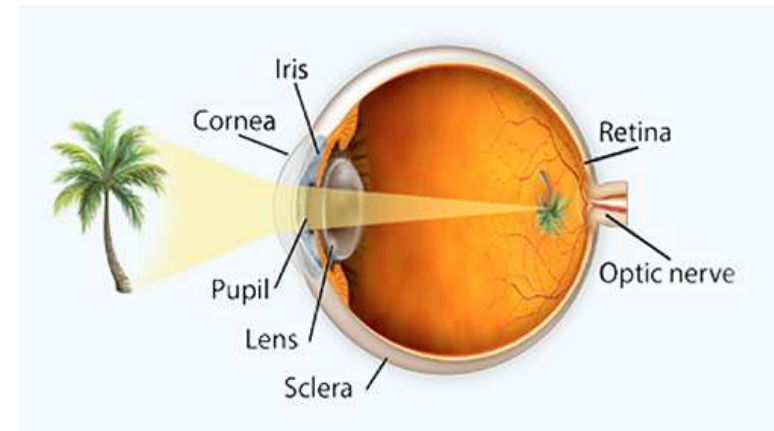# Conclusions

Search for an exact understanding of vision began long before the compilation of Euclid's *Optics* (around 300 BCE). This quest for an exact science of eyesight was being called ***Perspective*** for centuries before Brunelleschi organized the drawing method now bearing the Perspective name (during the early 1400s). In 1604 Johannes Kepler spread the paradigm that human eyes work like a *Camera Obscura*.

Perspective has been, first-and-foremost, a discussion about eyesight, and secondarily (consequentially) a method of image-making in the Fine Arts.
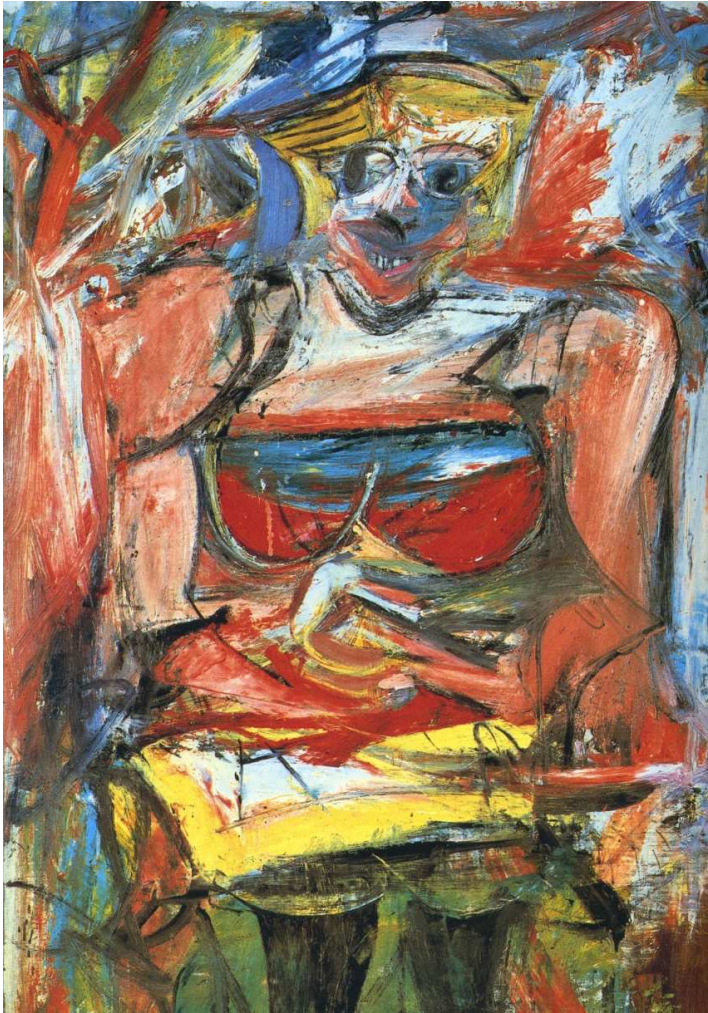
1953: "Woman V" -- Willem de Kooning

I grew up during the heyday of *Abstract Expressionism*, when one was supposed to learn that Perspective had failed and was being supplanted by a new understanding of vision (being imparted to us by masters of art such as Willem de Kooning).

Yet a century after the beginning of Modern Art there is still no complete understanding of eyesight, only a large collection of isolated non-Perspective observations (which this book has tried enumerate).

This book will end by discussing conclusions -- how I understand the relationship between Perspective and eyesight.

In general, my conclusion is that *Perspective*, as an ideal theory of vision, is as close as one might hope for an eternal and universal principle of nature. **I expect that *Perspective* will continue to serve as our simple central unifying model of vision.** At the same time, new theories of how eyes and brains work will need to ignore *Perspective*, in order to establish better theories with more detailed explanations. Nevertheless, *Perspective* gives geometric structure to the sight lines arriving to the Eye, therefore, as a theory of vision, Perspective will *not be replaced* – it will be *expanded*.
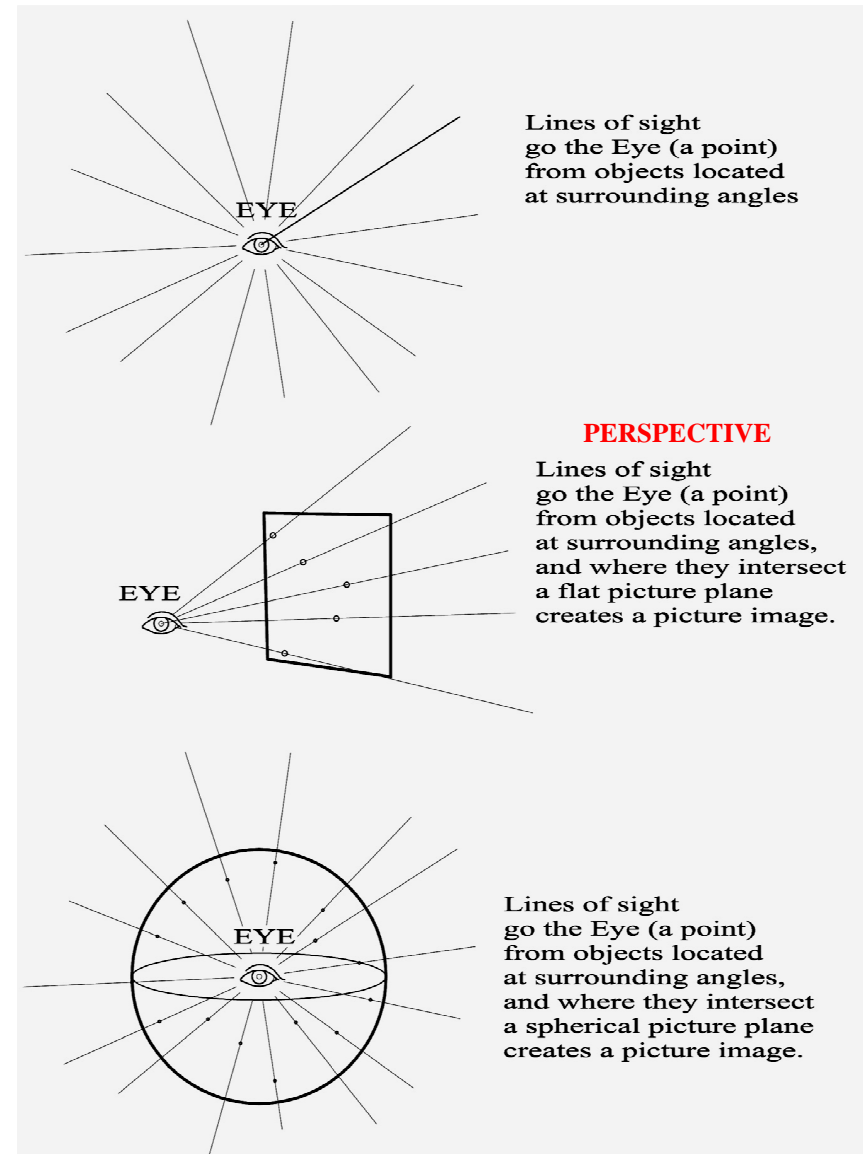
4a. Perspective: only the structure of a view

Constructing a precise Perspective drawing on a blank drawing surface is a fairly complicated geometric task, but the underlying theory is utterly simple. It is impossible for me to imagine any other mathematical model simpler or more economical.

It is possible to consider Perspective as nothing more than the model of the structure of a field of view, having nothing further to do with the mechanics of vision or eyesight.

Let me further explain this in the style of a geometric "proof". At the beginning of this book, the following diagram defined Perspective (seen opposite -- on the following page). Three geometrical modes were accepted, with the flat picture plane projection being the most commonly used form.

Lines of sight
go the Eye (a point)
from objects located
at surrounding angles

PERSPECTIVE

Lines of sight
go the Eye (a point)
from objects located
at surrounding angles,
and where they intersect
a flat picture plane
creates a picture image.

Lines of sight
go the Eye (a point)
from objects located
at surrounding angles,
and where they intersect
a spherical picture plane
creates a picture image.

We may reconfigure this diagram of Perspective so that the solitary Point which we assumed to be our Eye becomes a small Peephole. The human eye (along with its brain and other thinking apparatus) can then peer through that Peephole. Geometrically this divides everything into two distinctly separate spaces – all the Perspective geometry is in front of the Peephole, while all the Psychological equipment and neurological programming is behind it.
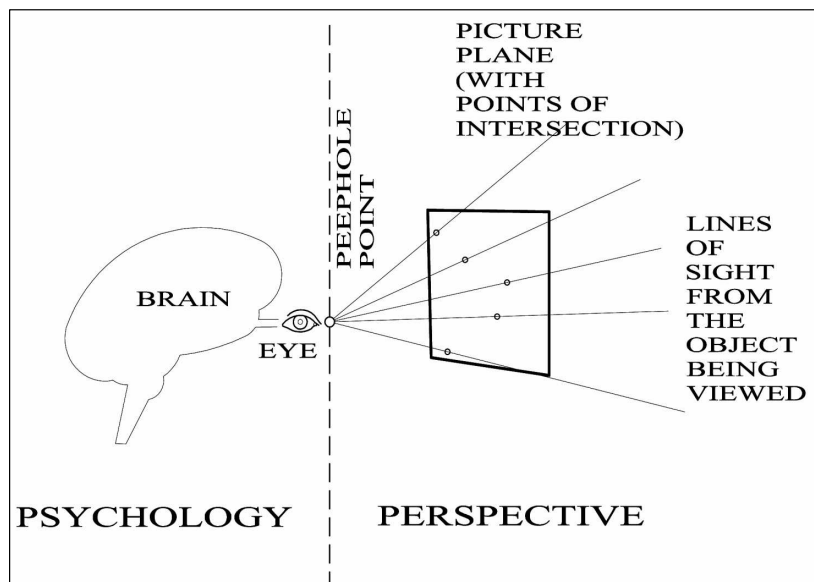
SOLUTION #1: This separation might completely solve this book's initial contradiction. *Perspective* is an exact simulation of the geometric structure of the field of view – of this there is no dispute. Eyesight could then be a completely separate problem. Contradiction eliminated!

After sight-lines pass through the "peephole" any manner in which the eye and brain then deal with those sight-lines might be deemed a secondary "add-on" program, purely mental (or biological) effects. The brain can then use, or ignore, the exterior sightlines and invent (or recall) other images in accordance to other rules.

I could easily imagine the majority of a brain's "visualizations" as having nothing to do with the momentary exterior Perspective.

Secondary remarks about this Peephole diagram:

Firstly, this diagram explains the oddity of how this book can provide illustrations showing why eyesight differs from Perspective by using a series of Perspective images –Perspective is simply the exterior presentation which the eyes and brain process into vision.

Secondly, I admit that this diagram's separation of the Perspective model of the field of view from the mental processing of the eye is not completely "air-tight". The peephole (pinhole) ignores consideration of the physical width of light waves (photons), and it completely ignores the binocular nature of humans having two eyes. I consider these problems as relatively trivial.

Thirdly, I would like to caution that I do not condone using this diagram to employ Perspective drawings (or photos) as surrogates for real objects in experimental tests of perceptual psychology. The angular arrangement of sightlines may be the same, but the intensity of light energy and the necessary reduction of detail in Perspective illustrations are readily detected by human eyes. Our eyes are keenly aware that a picture is different from a real view. To assume they are equivalent introduces new experimental risks.

In general this diagram shows why *obsolescence* and *replacement* are not the future of Perspective (in a mathematical science of eyesight), but its future instead is *continuation* and *expansion*. A theory of eyesight will always need this precisely constructed field of view.

4b. Our crucial assumption about vision.

What changes Perspective into a theory of vision is the assertion that the Eye sees what it receives.

We might call this an "assumption", "hypothesis", "postulate", "assertion", "generality", or "axiom".

As this book defined Perspective, this assumption would be stated: **The Eye sees every Sight Line** -- with the geometric order of the Eye's vision precisely conforming to the geometric angular order of sightlines arriving at the Eye (the peephole). Such vision is unlimited in speed, clarity, and continuity.

Making this assumption is the precise point in the formulation of Perspective where the contradictions cited at the beginning this book are generated. As a sweeping generality, this fundamental assertion is both indispensible and indefensible.

With this assumption Perspective becomes an *Ideal Law*. It is akin to *Boyle's Ideal Gas Law*, *Hooke's Ideal Spring Law*, or an *Ideal Friction Law* – being more of a practical generalization than a precise prediction of any one physical case. It predicts our everyday eyesight: "If you look at the sky tomorrow at sunset, you will see Venus 13 degrees above the Horizon, 5 degrees south of West". Using Perspective we then map the universe, great and small, by our vision. It silently serves as a fundamental rule of Nature. It provides our scientific Ideal Observer. As an Ideal Law, it extends our mental powers of visualization far beyond our biological limitations.

SOLUTION #2: We use this abstract "Ideal Law" notion to explain this book's initial contradiction – flipping its assumption off-and-on.

4c. Perspective entering the brain.

Since ancient times people have wondered how Perspective geometry gets inside the brain.   Medieval-European theory piped the "visual image" through the eye into the brain, where a "mind" had some sort of miniature movie-theater showing images from the outside world. Unfortunately the biology is far more complicated.

  In 1604 Johannes Kepler first popularized the concept that the eye functions like a *camera obscura*, taking the Perspective format into the interior of the eyeball. Unfortunately the Perspective model is compromised and complicated in each step of biological process. But by imposing precise limiting restrictions on our assumption of vision, we may refine our Ideal Law into specific predictions about eyesight. For examples -- We can make a simple prediction like: "We will not see anything indoors at night unless some sort of light is turned on"; or we may make statistical predictions about the probability of the loss of functional eyesight under certain conditions of "obstructing glare" produced by certain kinds of nighttime illumination.

During the end of the 20th century repeated efforts were made to program computers to recognize photos (Perspective) – to identify faces or surface features in surveillance satellite photo views. In the end, the Perspective-based programs were beat by self-learning-computer software. The recognition process is not simple. Why the brain thinks it sees Perspective remains a mystery in 2019.

The neurological processes we call "vision" are, in 2019, are still almost all beyond our understanding or ability to predict.

SOLUTION #3: We explain this book's initial contraction as a lack of specifications about how exterior Perspective sight-lines become interior mental thoughts called eyesight.

Sonia Lewitzka –1928 -- "Le Baiser" ('The Kiss")

4d. There will never be a single all-encompassing model of human eyesight.

There seem to be distinctly separate ways for separate individual humans to see, with different acts of seeing occurring at different periods of their lives; and with different acts of seeing occurring simultaneously at different levels of consciousness (perhaps in different parts of the brain). For these different modes of seeing, there should be different models of eyesight.

Eyesight is subject to learning, experience, and training.

Illustrated by our frequent admonitions *to "Look at that!",* or "*See what's going on over there"*, with respect to details within our view, we may conclude that different people see somewhat differently. **The more we bear down on a precise theory of eyesight, the more individual and moment-oriented vision becomes.**

In as much as eyesight is a form of thinking, it seems unlikely that we should establish any outer limit to our acts of seeing (thinking).

SOLUTION #4: This book's initial contradiction exists, and will persist, because we need an exact simulation of eyesight (in general) but (at the level of precise detail) there shall never be one.

I expect present researchers, or future theorists, might regard the way I have grouped different aspects of eyesight to be unfruitful. I do not regard my grouping method as necessary. Rewriting this book – providing concise but full review of eyesight for a general audience of readers -- is something that should be undertaken periodically (perhaps every twenty years or so) into the foreseeable future.

Which is better: Equation or Visualization?

In analytic geometry, a sphere with center (x_0, y_0, z_0) and radius r
is the locus of all points (x, y, z) such that:

$$(x\text{-}x_0)^2 + (y\text{-}y)^2 + (z\text{-}z_0)^2 = (r)^2$$

4e. Perspective as a geometric law

As a geometric model, Perspective is an extremely simple device. **Anything geometric can be viewed by Perspective.** Not only will it function in Euclidean geometry, but it also works with alternatives to Euclid's "5th Postulate" (the assumption that there exist parallel lines always at equal distances from each other). Furthermore, one might assume alternatives to Euclid's 4th postulate (which maintains that all right angles are equal), and/or one might assume a geometry without Euclid's 3rd Postulate (maintaining that circles exist). In all cases, the Perspective model (only points and lines) will work. So, a bunch of different variations using this basic model are feasible, and it is difficult for me to imagine anything simpler – given geometry as it is currently defined.

Could there be some sort of new alternative geometry? I suppose that one might take eyesight as the underlying principle and 'reverse-engineer' an alternative geometry; but, even if that were feasible, I cannot get enthusiastic about recommending such an invention.

During my lifetime the prevalent theme of Physics has been that everything is based on mathematics (algebraic equations). Forces like electricity, gravity, and quantum-scale bonding could never be seen by the eye – therefore equations must be used. What the role of visualizations – visual logic – might be was not, and is no,t being discussed. That seeing might be as significant for education and understanding as equations or verbalizations, is an unexplored topic.

While I am willing to give mathematical equations and precisely defined verbalizations a superior seat in the realm of Logic, I do not understand why visualizations are being so woefully neglected – except that many complex visualizations have only recently been made affordable by means of computers. **With no theory of the value of visualization, visualization remains relatively underdeveloped.**
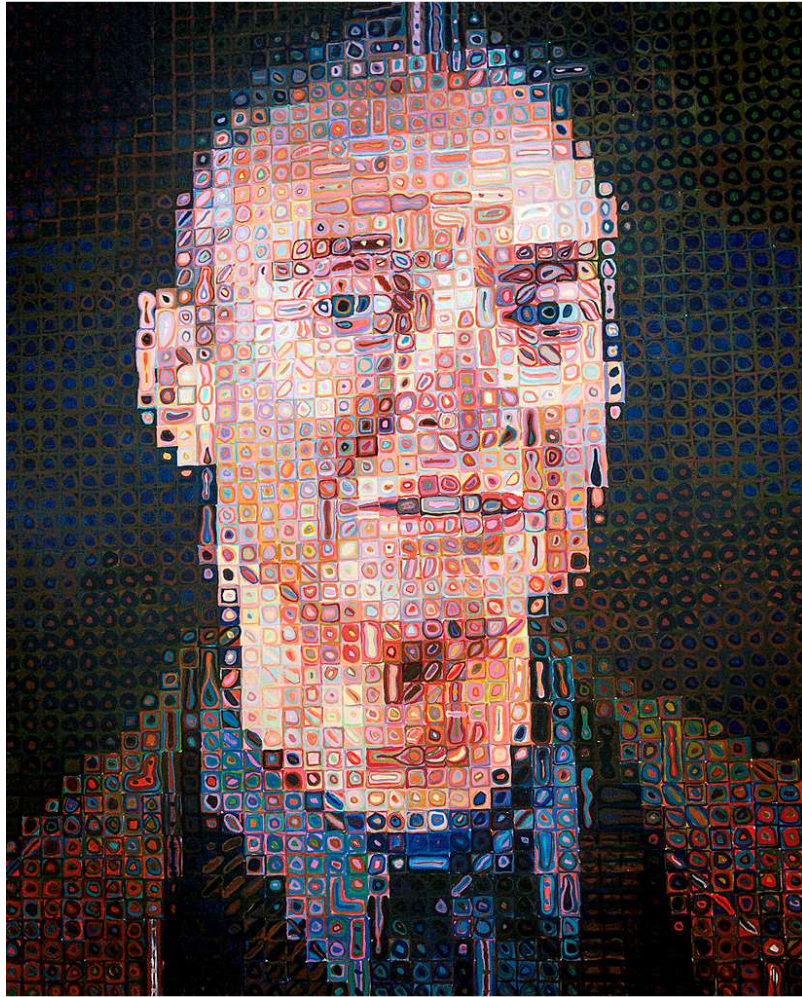
'Roy I' (Roy Lichtenstein) by Chuck Close

4f. Perspective as a method for Fine Art

Anti-Perspective attitudes of the late 19th and 20th century arose in the following manner. During the French Revolution, the academic study of Perspective got assigned to Art departments. Perspective gave art the appearance of "realism" – a requirement in the world of Beaux Art painting. The rebellion against Perspective, with its anti-Perspective rhetoric, arose (it appears to me) as a result of the invasion of mass-produced Perspective pictures in the form of photography. Modern Art arose not because of a failure of Perspective in common usage, but due to its success.

The rebellion against the Beaux Arts paradigm mandating Perspective in painting spread disinformation about Perspective throughout the culture.   Because Perspective had been made the academic topic of Art departments there was no immediate response from Science departments. Perhaps it is an example of Science needing to pause to permit advances in other aspects of culture. Or perhaps it was a failure of Academic leadership to take Perspective out of the Art departments and re-open discussion in the wider field of natural philosophy.

I myself see Modernism attitudes toward Perspective more as an expansion of the field of Fine Art than as a permanent change. Perspective images have never been more prevalent (as photographs). I would expect that the merit given to photography, movies, and Perspective paintings to be sustained, and to increase.

It is also possible to imagine that a more refined understanding of eyesight will enable Fine Art painters of the future to create works of even greater "realism" than simple Perspective (pictures looking more real than a photograph). The rendering of wide-angle fields of view is one obvious example where development might proceed. There is also the possibility (suggested in Impressionism) of creating surfaces which the observers' mind will use to generate a mental image — the final details of realism induced in the observer (rather than copied on the surface of the painting).

Perspective image derived from ultrasonic waves.
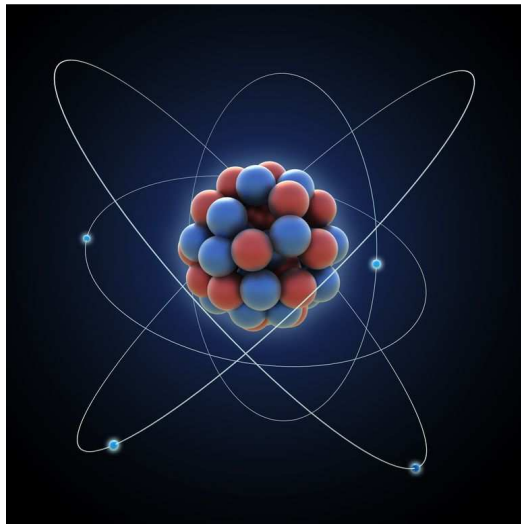

"Atom" by Andrzej Wojcicki-- 2018

4g. Progress on both sides of the peephole.

So, I see (and foresee) progress in Perspective proceeding by various efforts on both sides of the Perspective "peephole" – both sides of our initial contradiction create bases for future progress.

 Out in front of the peephole, I see various new methods being invented to capture "Sight Lines" for observation as Perspective images. And I see various new methods being developed to visualize all sorts of theoretical models –the "new" physics of the 20th century – Relativity, Quantum Mechanics, all the new models of Geometry. Every aspect of Chemistry, Physics, and Biology could be visualized, shared, and understood by a far wider audience through the use of the commonly understood Perspective method of projection.

 Behind the peephole, I see various ongoing developments of new models of mental cognition (neurological performance) and various man-made simulation devices.   If we could better understand how a brain maintains an interior mental construct of an object or event – how it projects that internal memorized construct onto the incoming Perspective sight-lines to recognize old familiar patterns, and to learn new ones, it would go far to understanding human eyesight. For example, in the future we may better understand how humans are able to recognize faces, at the same time that we invent machinery better to able to recognize those faces, and the momentary attributes of those faces, by means of photography.

 The possibility for new development, on both sides of the peephole, is huge – is unlimited.
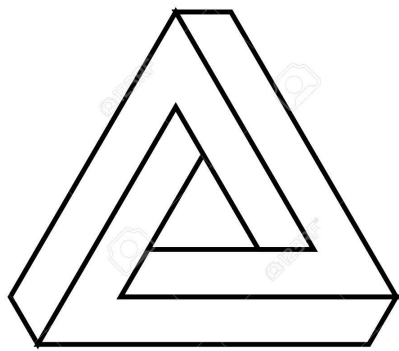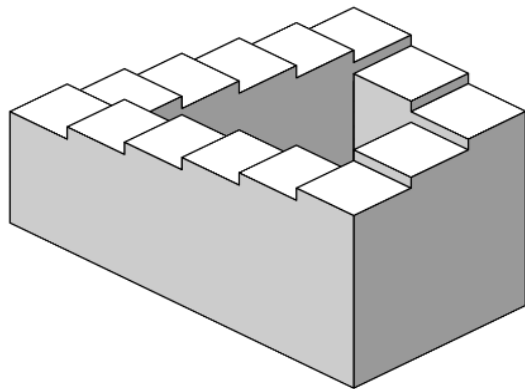
" Impossible Figures…" -- L.S. Penrose & Roger Penrose, 1958

(*Perspective Advances*, Barnes, 1989, page 39)

4h.   Reasons for the study of Perspective

My best reasons for continuing study of Perspective are as follows:

Technology:
   There are possibilities for new technologies of measurement and observation – new medical surveying equipment, new astronomical telescopes and planetary observation equipment, new microscopes, and new robot controls.
   Perspectives also serves as the lead graphic illustration method in a broader family of visualizations about how machines and biological systems can be built and operate. It lets us "*see how things work*".
   Perspective is a basic tool for building better Art and Science.

Education:
   As important as material profit is, I contend that there is even better reason for Perspective. It expands human knowledge. Perhaps when we look at the Perspective illustration of a proposed structure, not everyone fully understands how all the complex components will function, but they can envision how this particular place might affect them. A better world depends on a well informed judgment. Perspective economically informs us of complex arrangements.

Moral Expansion:
   And most importantly, Perspective is a relatively easily digestible form of extending the boundaries of our morality.   It gives us understanding of the causes which have created our predicament, and it shows us the proportionate consequences of our possible acts.
   In everyday jargon: "*We could then see what's going on*" -- and be able to "… *put things in proper perspective*".

(End)