Organic Geometry—A Rationale to Create a Form

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Abstract: The use of the word ‘organic’ comes from ‘organic chemistry,’ and refers to something that has life. The term should not be misunderstood to mean a natural shape or organic form. By ‘organic geometry’, one refers to geometric forms that can grow and develop according to the principle of geometry, similar to DNA in the biological world. The important knowledge of geometry will be discussed and analyzed in this article.

Throughout the history of humankind, from the early Greeks until today, in both Western and Eastern cultures there are many examples of geometric forms whose beauty transcends time and space, such as the ‘golden section.’ The construction of the ‘golden section’ is one example showing the process of ‘organic geometry’. The secret of the beauty hidden in the ’golden section’ is based on irrational numbers, and the only source for a form with irrational numbers is geometry.

‘Organic geometry’ depends on the use of only three drawing instruments: T-square, triangle, and compass. With these three, the three basic shapes of square, equilateral triangle, and circle are created. Just as the three basic colors: blue, yellow, and red can be mixed together to create any color, the three basic forms can be ‘mixed together’ into any shape or form using the principles of ‘Organic Geometry’ without the use of measurement, estimation, or guess work. Then the new form can be enlarged or reduced to any size without difficulty.

When ‘Organic Geometry’ is used, the same beauty, wisdom, sensibility, and reason experienced in the ‘golden section’ will also be found in the new form.

This paper will introduce the principle of ‘Organic Geometry’ and will also present examples to illustrate each step from basic to advanced ‘Organic Geometry’.

Key words: Organic Geometry for the designer

1. Knowledge of Geometry is Important for an Art Designer

Geometry should be a required course in design education. Nowadays, many visual artists have little knowledge about science or mathematics; since they tend not to excell in these areas, they choose art as their careers. Geometry is one branch of mathematics, and of all the courses required of art students, geometry is the closest one to the arts. Because it is a visual science, one needs to use one’s vision to observe, to solve a problem, or to prove a theorem. Sometimes one needs to search an auxiliary line to help solve geometry problems. This is very useful training for designers who are able to visually find problems in design cases. In art, often one uses terminology such as structure, pattern, proportion, symmetry, order, harmony, unity, and rhythm to refer to the
relationships of the work. These can be expressed by geometry. In the technical side of design, one often uses principles of geometry as a tool, such as 'divide a circle in half,' ‘find a center,’ ‘draw a tangent line,’ ‘draw to scale,’ and ‘enlarge in proportion’ in creating the final work. In practical applications, designers need to know how to draw a parallel line, different angles, perspective, and find the shadow. There are two measuring systems: the British and metric systems. These two systems can never be exactly converted to each other, especially when more than two parts are changed to the other system. If the form is created by geometry, one only needs the first unit converted to the other system, and the remaining proportions will automatically following the geometric construction lines. Designers need to understand the principle of geometry. More reasons will be explained later in this article. A geometry course should be prepared for design students.

Geometry composition also represents wisdom. There is a story about the Greek philosopher, Aristotle, who took his students on a boat trip and landed accidentally on the island of Rhodes. After landing, everyone was worried about being attacked by dangerous wild animals. Suddenly, the students heard Aristotle yell excitedly and loudly. He pointed at a geometric figure on the sandy beach, and then told his students that they were safe because there were wise men on the island. At the beginning of the 1967 movie ‘2001 A Space Odyssey’, a group of apes were playing with the oldest tools known to mankind—bones, and dancing around a square, stainless steel column. This scene strongly represents two different levels of culture. The apes represented the current level, while the existence of the square column indicated that a higher level had once been there.

In design history, people have passed through different style periods. Some of the new styles will surprise people at first sight, but will eventually go out of fashion, thus representing only one brief period. However, design with pure geometric shape will never go out-of-date. Only this form creates a wise, fresh symbol. It is timeless, like the pyramid. Pure geometry, just as pure water, is something one will never get tired of.

2. From Golden Section to the Modern Grid

Two thousand years ago, the Greeks understood the visual principle of geometric composition such as the golden section. People found the relationship to the golden section, from the period of early Greek vases [1] to the Parthenon in Athens. Throughout history a great number of good art works have been created from geometric division or geometric composition. Even in the Medieval Age, many bookmakers fully understood that well-defined, intentional geometric proportions are more pleasing and beautiful. Around the late 19th century, book pages designed without geometric division were considered ugly. Geometric shapes became as important as a craftsman’s tool for some artists. The great Albrecht Dürer (1471-1528) designed Roman letters by imitating the lettering in Roman inscriptions made by the pen.

Fig. 1 Albrecht Dürer: Construction of Roman Letter (1525)                                             Fig. 2 Joost  Schmidt: letter ‘a’ (1930)
He arbitrarily constructed them by using different sizes of circles, without specifying the radius or position (fig. 1). Four hundred years later, in 1930, the letter ‘a’ designed by Joost Schmidt has some of the same problems as Dürer’s work (fig. 2), but by 1932 he had improved this letter, as can be seen in the book about Bauhaus. This will be discussed in a later part of this article. Another example is Johann Neudörffer’s (1660), construction of Latin capital letters in which the basic square is divided into 10 equal parts. In organic geometry this type of measurement is not allowed! In geometry, one cannot divide into ten parts. Later, around 1950, the ‘Modular’ was developed from the Golden Section by the late, great architect Le Corbusier, who during World War II in Paris became the most important inspiration for graphic designers living and working in Europe. A new system ‘grid’ was created [2], which became a major movement, and has dominated the graphic design world for the last 40 years. It enables an artist with skill and sensitivity to produce a handsome and pleasant page design, but for the less able designer, working with the ‘grid’ is not easy. Even today, many designers work with the ‘grid’, but do not understand the visual principle of geometric composition. They totally forget that in early civilizations the beautiful, classic geometric composition was fully developed. This is why so many ugly graphic works were produced. This paper will introduce a new method ‘organic geometry’ which will help anyone, despite his artistic ability, to be able to create strong design work. This paper’s purpose is to help one to learn and understand three basic shapes, the closeness of the relationships of these shapes, and by using one of these three shapes, proceeding with geometric principles to create new forms. This is a simple method to create a form in a rational way.

3. The True Meaning of the Golden Section

Using the construction process for the Golden Section as an example (fig. 3), first draw a square and then a line to connect the midpoint of the bottom side to the upper corner of the square. This line becomes the radius of an arc.

![Fig. 3: Golden Section](image)

The arc determines the length of the bottom line, which is extended. From this point, draw a vertical line to connect with the top extended line. The newly created rectangle is what one looks for as the ‘golden section.’ If the side of the square is ‘1’, the other side of rectangle is \(\frac{\sqrt{5} + 1}{2} = 1.618\). This is an irrational number and cannot be measured. In history, people find many architects, artists, musicians and mathematicians who apply the golden section in their work. This paper will not expand on those achievements, but will emphasize the golden section’s drawing process, an important process — from a ‘square’ as a seed, followed by a whole growth process from one step to the next, which is called ‘organic geometry.’ When one understands the meaning of this construction process, and if all geometric compositions are drawn according to this principle, then one starts from one of the three basic shapes (square, equilateral triangle, or circle respectively), and step by step, following the
principle of geometry, without arbitrary judgment, draws lines or finds a circle of the center or the radius. The final composition will be as pretty as the golden section.

4. Square, Equilateral Triangle, and Circle Are Related to Each Other

In this section, even for students without a mathematic background, a series of assignments can help them build up the powers to understand geometry.

The three basic shapes: square, equilateral triangle and circle, are not strangers to each other and are like blood relatives to each other. These relationships are very important factors in working with geometry. No one has pointed out these important factors.

The shape of a square can be used as a compass to draw a circle. Draw a circle with a right angle. First, fix two points apart as a diameter, and force both sides of a right angle moving along against the two points, marking the trace of the corner of a right angle. The result will be a half circle. This is how a right angle relates to the circle, and vice versa. Connect the two ends of the diameter to any point along the perimeter of the circle, then one gets a right angle. Using the length of the radius of a circle, divide the circumference into six equal parts, then connect every other point along the perimeter of the circle to get an equilateral triangle. Also, if one divides a circle into four equal parts and then uses straight lines to connect the points that touch the perimeter of the circle, a square can be found (fig. 4).

![Fig. 4: Relationship within three basic Shapes](image)

Here proves that the three basic shapes are closely related. When one combines these shapes, one should not do so randomly but consider their relationships following the principles of geometry. This is the key to organic geometry.

5. What is ‘Organic Geometry’

These three basic shapes can be treated the same way as one would treat the three basic colors — red, yellow, and blue. Mixing different proportions of these three colors creates numerous colors, and in the same manner, mixing a portion of three different shapes creates numerous forms. This is not to say that it can be done in any way or even randomly. One needs to identify the basic shape of the ‘seed’ in a sketch and proceed step by step toward obtaining a perfect form. In the drawing process, every step is rational and simplified, so that the process of obtaining the final form is an experience of enjoying beauty. One should remember every step in the process — just as a good chess player is able to recall all of his moves after the game. This is because every step requires a process of careful thinking. A good form is like a delicate crystal, or the delicious bowl of soup that emerges
after careful preparation, and discarding the sediment after the long process of stewing. It is also like a beautiful poem, composed of only the most perfect words.

After explaining how the three basic shapes are related, the next project helps students understand more about any one of these basic shapes has the potential to be a starting point in the search for the other two basic shapes. Here one uses an equilateral triangle as the starting point, likes a seed from which the related square and circle are found. In this way, there are always harmonic proportions among the three shapes. Students are asked to keep all construction lines as a record of the search process. After the students understand the three shapes and their ‘blood’ relationships and by using organic geometric methods, they can develop and apply the method to any design, specifically in graphic design. There are many different possibilities (fig. 5).

![Fig. 5: Triangle as a Seed for Finding A Circle and A Square](image)

Another project for the students is to design a ring (fig. 6) with a known circle of any size. Then, another circle is to be created, bigger or smaller than the existing one, with the conditions that the two circles cannot cross over each other, and cannot have the same center. The size of the new circle and the location of the center points must be determined from the existing one according to the principles of geometry.

![Fig. 6: Design a Ring](image)

The *logo design* project uses two alphabets of the student’s own initials, then attempts to combine these two letters into one in order to create a new form. All design projects need to start with a free hand sketch. It is best to forget about geometric shapes in the beginning of the thinking process. If one starts with a particular geometric shape, then it is very difficult to break away from the limitation of this image. Pick out an interesting idea from a number of sketches and develop it. Use geometric shapes to analyze and discover which shape (square, equilateral triangle, or circle) can be used as a seed. Throw away extra, unnecessary, conflicting, and irritating parts. Gradually correct any flaws until a new form is created. All parts have geometric compositional relationships. The portion of each part is geometrically decided.

Following are some results from first-time design students in the latter part of a one semester’s assignment. Many professional designers have been surprised by the quality of their logo designs. Even for beginning design students, working with organic geometry can raise their work into higher levels in a short period of time. The finished result, with its construction drawing set next to it, is presented to let you understand the process (fig. 7).

While some used a square as a seed, others used a circle or a triangle in following examples.
6. A few Applications of Organic Geometry

In applying organic geometry to develop into different scales, one can follow the same construction-lines of the diagram without any difficulty. Besides the logo design, there are many other design possibilities. Take the universal ‘forbidden’ sign as an example. It is already an international part of the visual language for no parking, no smoking, no left turn, etc. The different sizes of the bright red circles with a diagonal line crossing through the middle are drawn inconsistently. Some have thick lines, some with thin lines. There are no standards for this globally accepted symbol. Using organic geometry, a construction diagram for standardizing this forbidden sign is needed, which will help clear up the current mess. One example of a design is shown here (fig. 8).
The egg’s graphic form, developed from a circle as in the construction-line diagrams, is one of many good examples that exist as the organic geometry. This form is used by the Olympus camera as a lens’s cover.

Use the “5 in One” table-top form to explain the process in creating a real product (fig. 10). First, there were a lot of freehand sketches (fig. 11). Then it was found that the relationship of the five centers of circles were right angles [3]. The whole graph started from a square. Using the right top corner of a square as a center of the first circle, and using the length of the square’s side as a radius, a circle was drawn. The first circle cuts the diagonal line, and uses the remaining length for the radius of the second circle, with the left bottom of the square corner as the center. The second circle intersects at the bottom side of the square. The third circle center is at the right bottom corner, with the remaining length of the bottom side of the square for the radius. The circle intersects the other diagonal line. The remaining length is the fourth circle’s radius, and it is centered at the left top corner. The number five circle is at the center of the basic square, with a radius of half the length of the diagonal line, and it completes the process of the ‘5 in one’ form. The number one, five and two circles share the same tangent line, and the number four, five and three circles share the same tangent line.
The following is another example of a site plan for an astronaut memorial proposal, based on organic geometry. To design the place of a spherical shaped dome placed off-center in the middle of a water pond, the size and placement were found the same way as the ring construction method introduced early.

7. Proof that Organic Geometry worked for the famous ‘a’ letter design

As mentioned in Section 2, Joost Schmidt designed the ‘a’ in 1930. Fig. 2 shows how the form was created with eight circles, clearly marking the center for each circle, but without any information how the location and the size of each circle was determined. In 1932 [4], he redesigned it, giving more information about constructions of this letter with some rational measurements as indicated in this diagram (fig 13). All the dimensions are useless.
Those rational numbers are not enough for constructing the letter and it is very hard to convert to any scale in order to enlarge or reduce this letter form.

Apply the organic geometry principle to recreate the ‘a’, without using any measurements in the drawing process (fig. 14). Using Joost Schmidt’s diagram as a sketch, start with a circle. The process is illustrated in a series of diagrams leading to the final result. Compare the two solid ‘a’ forms in fig. 13 and fig 14.

Organic geometry is the process of construction following the principle of geometry without using any measurements except the starting unit. By following the process of construction lines, the form can be drawn to any size.

8. Three Forbidden rules

In addition to the process of ‘Organic Geometry’, there are three forbidden rules for all designers:

1. No grid is allowed. The grid is often used for enlargement in advertising billboards, or is used in stock market report diagrams, or in medical graphs. With a grid one only gets an approximate duplication, not an accurate or precise duplication between the intersecting points.
2. No French curve is allowed. If designers use a French curve to get a partial curve, then it is hard to
enlarge or reduce the graph for production later. There is no precise measurement; one can only use
a grid or photo technique to enlarge or reduce it—not geometry. With the organic geometry, based
on one unit as a base, one can enlarge or reduce it without any limitation.

3. No rational measurement is allowed. The forms from rational numbers are too mechanical and
predictable. Sometimes there is a measurement error involved when there is a need to change the
size. The inconvenience of conversion may produce another error.

When making a form, there is only one basic unit, such as a radius of a circle, a side of an equilateral triangle
or the side of a square. The goal is gradually to develop a form from one of the three basic shapes—circle,
equilateral triangle, and square—using geometric methods. The form created from ‘Organic Geometry’
represents wisdom, reasoning, and sensibility and will never become outdated.

9. Conclusion.

Designers must understand the irrational numbers inherent in the forms. In other words, designers should
abstain from arithmetic measurements, and instead use geometric theorems with geometric construction methods
to obtain any form.

Irrational numbers can be obtained only through geometric methods, not from the use of arithmetic
measurement. As with the ‘golden section’, a new method of using rational design to create a form with irrational
numbers can be called ‘organic geometry’. Such a form is not static but more dynamic.

References