THE RAINBOW

Box Art Group Newsletter - Friday 21st July 2023

Written by and for the members of Box Art Group (No. 88)

Contents

Holiday Sketches

A couple of in situ sketches from my recent trip to Pembrokeshire. *Michael*

Plein Air

Several members enjoyed an outdoor session with tea and cake in Jose's garden a few weeks ago.

The house featured in a couple of sketches, but it appears the cake took precedence over sketching for some of us….

Michael

Pete

Summer Competition

The summer competition is postponed as Beth will be unable to support the group next term, but hopefully she'll be back with us next year to provide a critique. In the meantime, Roxy has agreed to cover the exhibition and many of Beth's sessions, and the committee is exploring the possibility of arranging a temporary tutor.

More Geese

I've had another go at the Peter Scott style geese, but with the blue sky toned down from the previous effort. See issue 87.

Pete

For Sale

We've had a dozen blank canvases donated to the club, which members might wish to buy, priced as follows:

9" x 12"	£2 ea	4 off
10" x 14"	£2	1 off
12" x 16"	£3 ea	2 off
18" x 24"	£8	1 off
20" x 30"	£10 ea	2 off
23.5" x 33.5"	£10	1 off
25" x 30"	£10	1 off

Also a zipped A4 size portfolio case, £3
And a full size studio easel, £50.
Please contact me at 883611 or peter@lyonspace.co.uk for details.
Pete

Local Exhibitions

There's a wonderful exhibition of Quentin Blake paintings at the Slimbridge WWT. It's on until September.

The Patterns behind Patterns

Elaborately decorated “Beaker" pots dating from 2500 BCE have been excavated in the UK. In Japan decorated pottery of the *jomon* culture date to 14,500 BCE, and in China the Xianrendong Cave contained pots with simple patterns, but nevertheless patterns, dating from 18,500 BCE. In Egyptian tombs one can find elaborate and complex decorative patterns that clearly required more than casual understanding and later Islamic artists - forbidden from representing human forms - developed dazzlingly virtuosic decorative skills. Many of us wear patterned fabric and some live in houses decorated with patterned paper on walls topped with regular friezes and wash in bathrooms covered in patterned tiles. Gardens were at one time exercises in regular planting.

Figure 1: Beaker pot
(*from Wikimedia Commons*)

There is clearly something in visual regularity which appeals to human minds and it should not be surprising: biologists point out that the evolutionary drive for intelligence is about predicting future events - and so enhancing survival chances - based on recognising patterns in the present and past and project them into the future.

You might well reasonably argue that the contemporary artist wishing to make decorative patterns already has twenty millennia of practical experience on which to draw, but it often takes time and exceptional aptitude to learn skills by example. Codifying knowledge, on the other hand - in this case the deep patterns underlying visual pattern making - smooths the path to mastery. In this case some of the codification can be sufficiently precise that we can create software tools which facilitate the less creative parts of the job, though the artist will always require some understanding of wider aesthetic principles.

I make no claim that you will learn anything here that will turn into saleable art: I just like talking about these ideas, and perhaps you may find some of it interesting - or maybe not. It is up to you.

Symmetry

Any regular pattern is an expression of symmetry. Over the last couple of centuries mathematicians and scientists have steadily extended the naive ideas of symmetry with which we are familiar in everyday life, and have also discovered that it seems to govern the very nature of the physical world at a fundamental level. Just as the symmetry of visual patterns lets us predict the appearance of the whole from one of its parts, these deep symmetries allow us to discover physical laws that predict the future from the present and the past.

As visual artists we tend to think about patterns in terms of the way things *look*. Our two hands have similar shapes but you cannot overlay one exactly on the other. Hold them to a mirror, however, and your right hand looks like your left and vice-versa. Mirrors actually swap back-to-front (not left to right) but in the case of hands a left-right swap and a 180 degree rotation around the long axis of the hand is exactly the same as swapping front-to-back. This is so familiar that most of us are unaware of the general rule, but it took genius to see that it is a significant and subtle observation about the properties of three-dimensional space, which can be extended (trust me) into one of the main foundations stones of modern mathematics. Fortunately, we need to take only tiny steps along this road in order to get some real pay-offs for art.

The first step is thinking about symmetry in slightly a different way to our intuitive visual understanding: we need to ask what happens if points in space *move* according to a particular recipe, called the *operation*. If the change leaves things the same in some sense then that *operation* has a symmetry property. Hence, rotating or flipping beer maps qualifies. They indeed might just look the same, but broader types of similarity also qualify. So, for example, changing every colour in a photograph to its complementary colour on the standard colour wheel is a type of symmetry operation because complimentary colours are reflections of each other in the centre of the wheel. In fact, we do have some intuitive understanding of these less obvious symmetries: every time we worry about "balance" in an artistic composition we are seeking to include other forms of symmetry.

Associating symmetry with something that *changes* rather than the way something *looks* is a surprisingly profound generalisation, because we no longer need visual representations to apply symmetry concepts. Alice's trip into the Looking-Glass is taking her into a world where everything has been flipped to a mirror image. She, however, ought not to notice anything different if she herself participated in the flip - but that is not the point of the story. An "unflipped" Alice might well discover that familiar foods had different tastes (providing she herself was unflipped) because our proteins and enzymes also have a distinct handedness, and biochemical reactions would go differently. The difficult here for Alice is the miss-match in handedness - flipping only part of the world. We could, of course, ask if the World would behave in the same way if we actually changed *everything* in the World for its mirror image. Could the world, in principle have built a right-handed biochemistry rather than our left-handed version? Would all of physics work the other way round? Until 1956 most scientists would have said "obviously it would", but in that year the physicist Chien-Shiung Wu showed that some types of fundamental nuclear reaction had a left-handed twist (emerging particles always spin one way and not the other) and if you look at that in a mirror the cork-screw motion would appear to have the wrong twist. The Alice-Through-the-Looking-Glass world really *is* different.

Don't Panic! That is enough about physics. As artists we can stick with visual representations for our examples. We can also, if we wish, just stick with our intuitive understanding, but as with most areas of skill, there are real pay-offs if we seek more systematic knowledge.

We now need to introduce a new type of symmetry operation: *translation*, which is just picking up our motif and moving it a set distance up or down, left or right, and then just keep on doing this out to infinity while trying to fill up space. (Repetitively moving a printing block used to be the actual method of printing fabrics, and the textile studio in Stroud at the John Street Art Space still has such a print table.)

In order to make a regular pattern on a flat sheet, you must build your design by repeating one of the five so-called "Bravais Lattice unit cells" (see Figure 2) which can be fitted edge-to-edge to fill

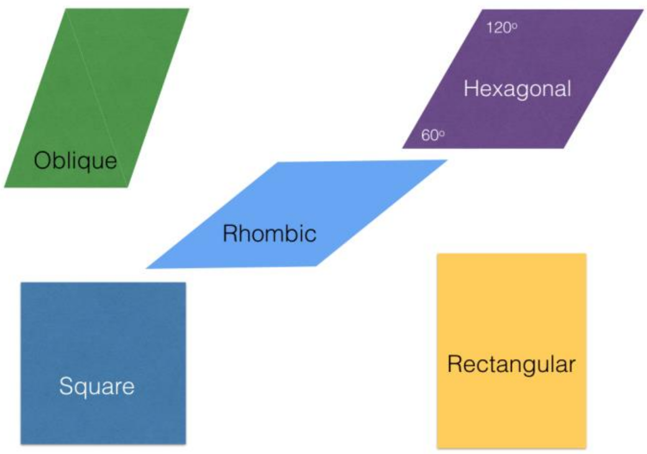

Figure 2: Bravais Lattices in Two Dimensions

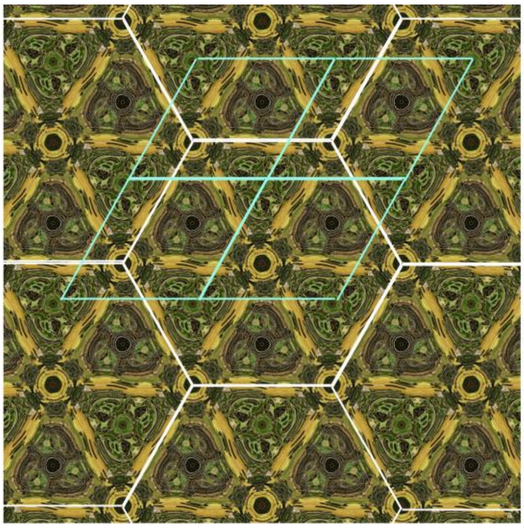

Figure 3 - Hexagonal Patterns really have quadrilateral unit cells.

up space. We can *prove* that there are no other shapes that work. You may remark that six-sided polygons (as I have on my patio) clearly fill up space, but it turns out that you can always redivide the space using the four sided “hexagonal” unit cell as I have illustrated in Figure 3, superimposing both a hexagonal polygon tiling and the “hexagonal” Bravais lattice.
In particular you cannot make regular space filling patterns with pentagons (but see below for the unexpected small print).

In these cell you inscribe your chosen motifs according to your aesthetic taste. To get a full understanding of potential wallpaper and fabric patterns we need to think about the types of motifs that we can put inside these unit cells and what these may do to the symmetry of the basic unit cell shape.

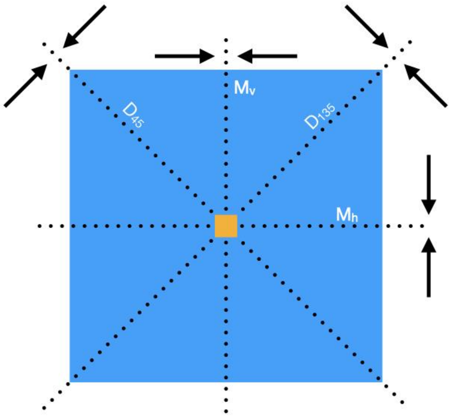

Figure 4: Mirror planes of the square

Figure 4 illustrates the basic symmetries of the plane square. (It can be helpful to have a piece of card, such as a beer mat at hand.) We can *rotate* the card around its centre by 90 degrees and get something that looks the same (forget any printed patterns on the front for the time being - look at its back). You can also flip the card across the planes of m*irror symmetry* i.e. that we shift every point to the left of an axis of symmetry an equal distance to the right of the line (and vice versa).

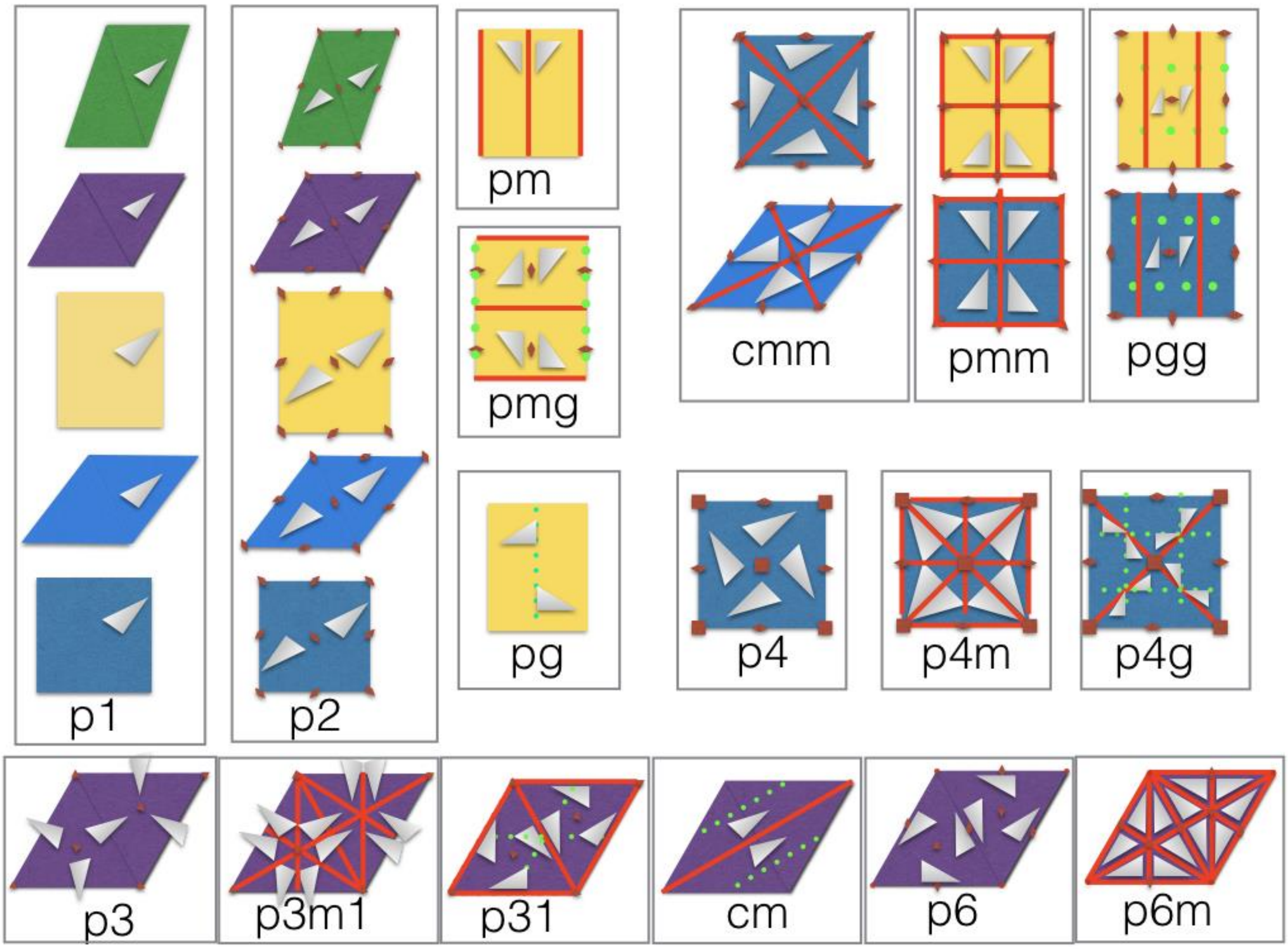

Figure 5: The Crystallographic (“Wallpaper”) Point Groups in Two Dimensions

Figure 4 shows that the square has four possible lines of symmetry (where the arrows show the direction of in which points move across the mirror plane).

Adding a motif inside a square (the front of the beer mat) could, for example, keep the full intrinsic symmetry in rotations and reflections, but if we could also place the motif so that it has less symmetry by, for example, putting it to one side.

When we look at all the possible combinations of symmetry-preserving or symmetry-reducing combinations on all of the five types of unit cell we get the seventeen *Wallpaper Groups* illustrated in Figure 5. more formally known as the *Crystallographic Point Groups* in two dimensions. (Mathematicians have a pernicious habit of using words according to Alice's advice: they mean exactly what they want them to mean and the technical meaning often has little to do with everyday usage. "Group" is the term mathematicians use when discussing symmetry for reasons that we do not need to explore.)

The red lines represent mirror planes and the small red triangles, diamonds etc show where there are points around which an entire extended regular pattern could be rotated by 60, 90 120 or180 degrees to get back to where you started. We also include an operation not previously discussed: the "glide", which involves a translation and a mirror reflection (so called because of the similarity to the scratch patterns made by ice skaters when moving forwards - some people prefer to think of it as a "knight's move" in chess). Look for a "g" in the label of the group to see where this occurs. The labels underneath the unit cells are just a conventional terminology for describing the groups in a logical way (though the logic takes a good deal of explaining, so I will not try). In each case you would, of course, normally replace the motif illustrated here by irregular triangles with something more pleasing to the eye, but keeping the same relative position.

Every regular two-dimensional pattern you have ever seen, or can feasibly design, can be matched with one of these categories. You can create any regular fabric pattern by choosing one of the wallpaper groups, drawing the shape of a unit cell, then decorating the inside, with motifs that either respect symmetry or break it according to the fundamental patterns illustrated above. (Yes, it does indeed have some real relevance to the practicing craftsman - these are effective recipes that you can productively use in everyday work as a fabric designer.)

Egyptian tombs have examples of every one of the seventeen possible "Wallpaper" patterns, so we know that one can work out the all variations intuitively, but most of us would probably miss some of the possibilities. (I always need to think hard about the ones including "glides".) You too could just use the recipes of Figure 5 to produce new fabric designs by hand, but it is more common these days to employ computer software that has built-in knowledge of these fundamental symmetries. (See for example https://singsurf.org/wallpaper/wallpaper.php, though some designers probably use plug-ins for tools such as Photoshop e.g. https://exchange.adobe.com/apps/cc/2304/wallpaper.) The designer just has to choose some motif and then watch it replicate according to the chosen recipe. It does not replace visual imagination, but allows it to explore more ideas more quickly. You do not need to understand much of the underlying theory to drive these tools, but as with perspective theory, a deeper understanding can

Natural Quartz Crystals - the external shape is a clue to internal patterns

sometimes stimulate fresh visual ideas.

You might well wonder why mathematicians spend so much time thinking about flipping beer mats and the rules for decorating walls (or if you know a mathematician, perhaps not). The somewhat more complicated symmetry rules that govern three dimensional shapes, however, turn out to be a really big deal. Solid matter, for example, acquires much of its properties because of the various structural symmetries adopted by the component atoms in crystals, and we can deduce some of the details by looking at the external symmetries of mineral crystals. I remember being taught about crystal symmetries as an undergraduate and having to sit through seemingly interminable lectures learning about all the different ways atoms can arrange themselves in regular ways - there are exactly 32 possibilities as compared to the 17 for a 2D plane surface. At one time (probably, in truth, just until the end-of-year exams) I could look at a crystal and tell you about its internal structure. This stuff, however, really does help scientists to understand why diamond is hard and the graphite in your pencil is soft - even though both are just different crystalline forms of pure carbon.

The molecular structure of important molecules such as DNA can be derived by scientists because regular atomic arrangements in crystals bend X-ray beams in ways that produce regular 2D patterns on a photographic plate and those directly tells us even more about the internal symmetry of its atomic arrangements. Physicists, chemists and crystallographers spend a lot of time learning how to use symmetry as a vital tool to solve significant problems in science and much of modern cutting edge physics involves sophisticated thinking about subtle symmetries.

Renaissance artists needed the formalisation of the rules of perspective by Brunelleschi in his seminal publication in order to produce the increasingly realistic representations of reality which then became possible. More recently, digital animators needed Mandelbrot’s formalisation of the rules of *fractal geometry* in order to automatically generate increasingly realistic digital landscapes, with fractal mountains, fractal trees, fractal waves and fractal clouds. These tools bring to the competent artist capabilities that were previously possible only for artists of genius.

There are digital artists today who are using their knowledge of maths, especially symmetry and perspective, to explore virtual sculptures created in higher-dimensional spaces - and then using perspective theory to interactively project them onto computer screens, so viewers can extend their senses through exploring four or five dimensional worlds.

Now a little digression. We have been looking at regular patterns that fill a two-dimensional space, leaving no gaps. We can, in principle, pick up the whole area and move it up, down, left, right by multiples of the unit cell, drop it down and get no conflicts of pattern. Furthermore, no one has ever found any way of incorporating a five-fold rotation symmetry into a pattern and we can prove this it cannot be done…. except if you relax the rules just *slightly* something fascinating take place..

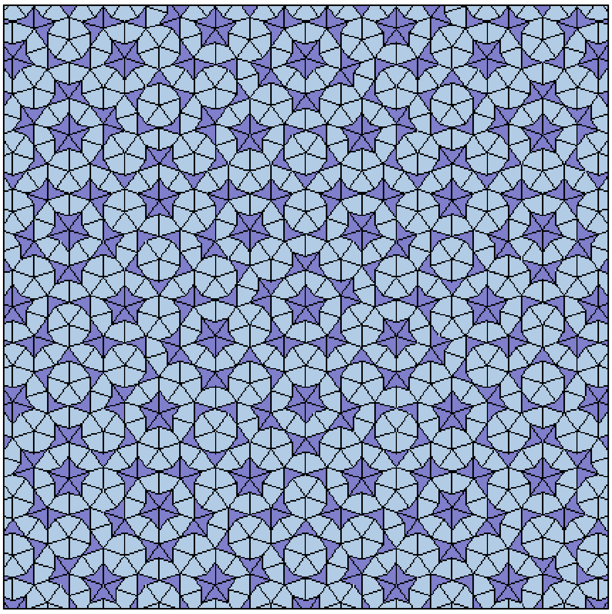

Figure 6: A Penrose Tiling

You could make all the above regular 2D patterns with identical tiles, or even a limited selection of tiles of different shapes, and it had been speculated that it might be possible to build space-filling patterns with almost fivefold symmetries if we allowed some slight irregularity (an *aperiodicity*) in the arrangement. Sir Roger Penrose the ingenious theoretical physicist who was awarded the 2020 Nobel Physics Prize for his work on black holes, was in 1974 the first to find an example of such an aperiodic tiling pattern. In fact he found several variations, one is shown in Figure 6, that are now known as “Penrose tilings”. (Sir Roger has serious form in connections with the visual arts: he is himself a very competent draftsman and was the joint inventor, with his scientific father, of several intriguing visual illusions, including the never-ending “Penrose staircase” that later figured prominently in the work of graphic artist M C Escher.)

Penrose tilings inhabit the border between regularity and chaos: even though there is no long range periodicity they still have some long-range order. For example, if you try to change the arrangement in one local area of the pattern, you will find that adjustments to the rest of the pattern needs to follow all the way out to infinity. In fact, you cannot lay down these tilings willy-nilly, starting with a few then working outwards. Along that road you will eventually almost certainly get to a configuration where it is impossible to fit the next tile. You can, however, now easily find software on the Internet that will automatically generate Penrose tilings in any size, because there are underlying and now well understood symmetry rules of a kind we have not explored which are to do with the way patterns on different scales can have similarities.

The maths department at Oxford in St Giles

If you ever find yourself wandering down St Giles, in Oxford, check out the forecourt of the Mathematics Institute, which has a spectacular entrance paving constructed using a Penrose tiling. Other architects have also employed Penrose tiling in various decorative roles, having discovered the strange visual attraction of these not-quite regular patterns and knowing that broken symmetries can be more aesthetically pleasing than perfect regularity.

The final twist in this story is the subsequent discovery by chemists of a new class of real materials now known as “quasi-crystals” (the discovery earned Dan Shechtman the 2011 Nobel Prize in chemistry) which exhibit the almost impossible five-fold symmetries in their not-quite regular atomic arrangements. The border between order and chaos turns out to be important in the real world too.

Next month I will show you how I use these ideas to generate patterns - but in a quite different way to simply drawing a motif and then repeating it: I use the shape of a musical note to transform original images into visual patterns expressing symmetry. (Figure 3 above is one such example.)

See my website at https://mcellin.me.uk/artfulcomputing/ if you want to know more or see many more examples my own work.

Michael

Painting the Sky

I attended a one day workshop at Pegasus Art one Saturday. The workshop “Sublime Skies in oils - in the style of Constable”, was run by Mark Stopforth, a visiting tutor an and professional artist. Only paper, oil paints, diluent and kitchen towel was required! Paint was squeezed direct from the tube onto kitchen towel and applied to the paper. We used a limited palette of 4 or 5 colours, rubbing the paint around and adding layers and blending in. Here are 2 of 4 paintings I completed, the second being A2.

There was thunder, lightning and heavy rain while we painted in the attic studio - very apt for the subject matter!

It was great fun and a technique I’ll definitely try again and will also try other subject matter.

Jill