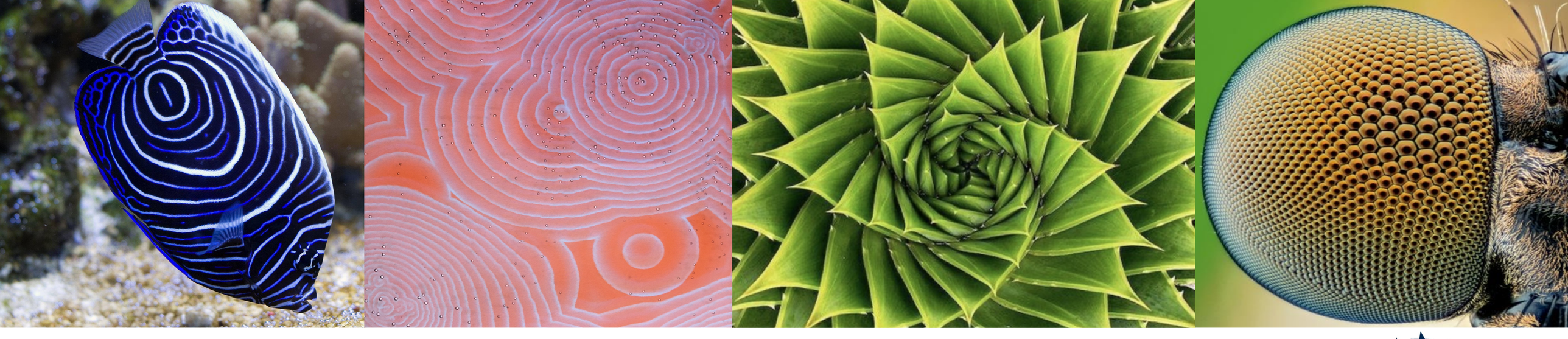


Construction of Life

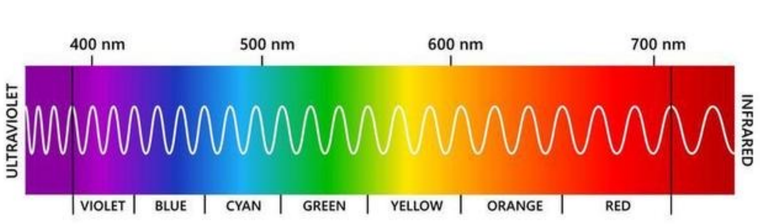
Investigation of Colors, Forms and Patterns in Biology and the Arts using Mathematics, Chemistry and Physics

Dr. Sacha Glardon and Dr. Cyrill Götz (Gymnasium Bäumlihof, Switzerland)

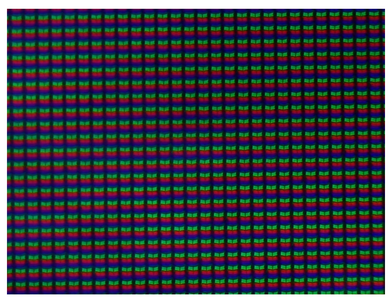
“Endless forms most beautiful and most wonderful have been and are being evolved” is part of the closing statement in Charles Darwin’s outstanding book “On the origin of species”. It is the aim of our project to investigate this diversity of biological form with the means of MINT topics and to connect it with Art. To achieve this goal, we divided the field in four different areas and within each area there are activities for different age groups. It is always connected with the search to find different patterns in organisms, followed by investigating and analyzing them with the means of Mathematics, Chemistry or Physics. In a second step the students use their knowledge to create their own work in an artistic way.
The aim is to connect the beauty of Nature and human Arts. This project allows students to analyze, calculate and construct, but beyond this to be astonished, marvel and admire.

Colors

The white light we humans are able to detect is a continuous spectrum of wavelengths ranging from blue (400nm) to red (approximately 750nm).



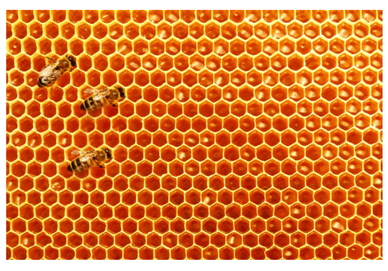
The reason why a biological object appears colored is either that part of the wavelengths are absorbed and hence only a fraction is reflected or due to interference some wavelengths are cancelled out. This activity will focus on the nature of light, generating absorption spectra of specific pigments and the workings of structural colors (peacock feather and butterfly wing).


Further projects:
- Color system and pixels on your smartphone
- Chromatography to separate pigments of plants
- Cyanotype of biological specimens

Tesselation

In nature regular patterns of specific geometric shapes can be observed. A prime example are the honeycombs. They are perfectly arranged hexagons, resulting in no gaps in between and hence occupying the available space optimally. In this activity the tesselation in biology is investigated and the impact it has on optimal surface-to-perimeter ratio.

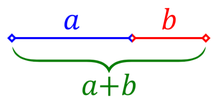


Further projects:
- Geometry: n-polygonal structures
- The art of M.C. Escher
- The art of moors

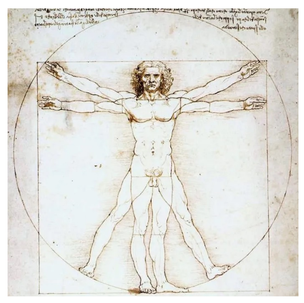
Golden Ratio and Golden Spiral

The Golden Ratio is describing two quantities behaving in a way that their ratio is the same than the ratio of their sum and the larger of the two.

$$\frac{a+b}{a} = \frac{a}{b} = \varphi = 1.618\,033\,988\,749....$$



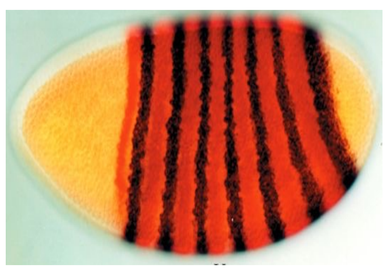
The Golden Ratio in nature is investigated using starfish, flowering plants and nautilus. The activity includes measurements with a ruler, working with a circle to construct a Golden Spiral. In addition, ImageJ is used as a digital analysis tool, in order to determine distances digitally and subsequently doing the analysis in Excel.


Further projects:
- Golden Section in the Arts
- Fibonacci sequence in nature
- Mathematical relationship between Golden Ratio and the Fibonacci numbers

Symmetry and Periodic patterns

In biological systems periodic patterns are widespread. In this investigation the spatially restricted expression patterns of the pair-rule genes *evenskipped* and *fushi tarazu* in the *Drosophila* embryo are discussed. It is shown that there is no sinusoidal up and down regulation of one single factor – but rather each stripe is laid out individually by a specific combination of transcription factors. The principle of morphogens is introduced and its key importance in conferring cell identity during early development described.



Further projects:
- Bilateral and Radial symmetry at the macroscopic level
- Chiral molecules in chemistry and their relevance for biological systems
- Belousov-Zhabotinsky reaction as an example of a chemical oscillator