Zoom into a Butterfly's Wing

Monarch Butterfly
(wingspan 8-12 centimeters)

The planet's roughly 20,000 butterfly species are amazingly diverse, ranging from New Guinea's massive Queen Alexandra's Birdwing (with a wingspan of 28 cm) to North America's 1.3 cm Pygmy Blue. The Monarch *(Danaus plexippus)* is one of the most familiar. It's also known as a *milkweed butterfly* because females lay their eggs on toxic milkweed leaves. Monarch larvae feeding on the leaves become poisonous to predators.

Monarch Butterfly Hindwing
(4 centimeters)

Wings allow butterflies to fly, of course, and may also play a role in temperature regulation. But their striking colors and patterns are their most noticeable (and beloved) aspects. The hues, shapes, and markings of butterflies' wings are important for camouflage, courtship, and species recognition. Monarchs' distinctive coloration warns potential predators of their unpalatability.

Wing Scale
(width 60 micrometers, or millionths of a meter)

The wings of most butterflies consist of a membrane overlaid with layers of very delicate scales. (In fact, the name of butterflies' taxonomic order, Lepidoptera, is derived from the Greek for "scale wing.") The scale layers usually contain two types of scales in alternating orientations, much like tiles on a roof.

Scale Ridge
(width 600 nanometers, or billionths of a meter)

A wing scale's upper layer consists of longitudinal ridges joined by transverse crossing structures, creating a gridlike appearance of repeating hills and valleys. Within the valleys, open rectangular pores reveal the scale's hollow interior and flat lower layer. Except for columnar pillars called *trabeculae*, the area between the upper and lower layers is largely empty.

Ridge Microrib
(length 150 nanometers)

The ridges on most butterfly wing scales are comprised of a lattice of microribs and *ridge-lamellae*. The bright orange in a Monarch's wing is produced by pigments in the scales. However, some species' microribs and ridge-lamellae (such as those of genus *Morpho*) create iridescent colors by preferentially reflecting light of certain wavelengths. This property has led to experimentation with paints, cosmetics, and other products in which colors are created by the light interference effects of nanoparticles.

Chitin Fibril
(diameter 3 nanometers)

Like other insects, the butterfly's soft interior is supported by a hard exoskeleton made of the carbohydrate *chitin* and a matrix of fats and proteins. Chitin is one of nature's most common organic molecules, found in insect and crustacean exoskeletons as well as the beaks of squid and octopi and the cell walls of fungi. The chitin in a butterfly's wing scales takes the form of long strands or *fibrils*.

Chitin Molecule
(width 1 nanometer)

Chitin fibrils are composed of molecular chains of oxygen, nitrogen, carbon, and hydrogen atoms. Strong bonds between chains give chitin its exceptional toughness. However, this also means that chitin doesn't stretch with growth—so insects and other arthropods periodically shed their exoskeletons, or *molt*. Some researchers study chitin's properties to create strong, lightweight materials; others explore its structure to discover new ways of combating insect pests.

Carbon Atom
(.15 nanometers)

Carbon is one of Earth's most common elements—and an essential building block of life. Carbon atoms can combine with other elements to form many types of molecules, from simple carbon dioxide (CO_2) to complex, long-chained molecules like chitin. Sheets of carbon atoms can also form *carbon nanotubes*. The lightness and strength of these tiny tubes have inspired both practical advances (such as super-miniaturized electronics) and fantastic new ideas (like elevators to space).

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