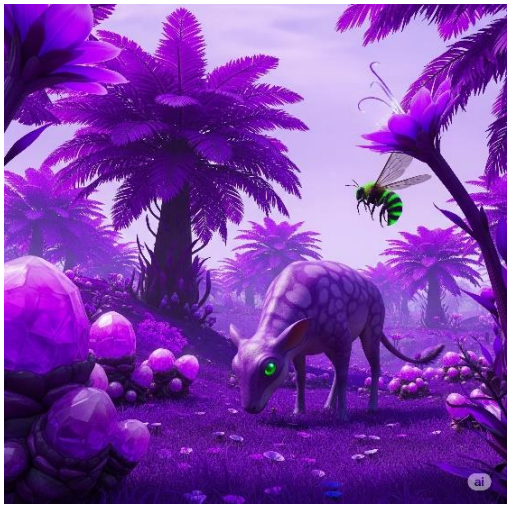
Worlds Beyond and Astrobiology Insights - Blog #13

Other Life on a Purple World

Christopher S. Centi July 29, 2025



My previous blog dated June 28, delved into the search for possible life on worlds using a different type of photosynthesis. Research by Lígia Fonseca Coelho's paper "Purple is the New Green: Biopigments and Spectra of Earth-like Purple Worlds," is fundamentally challenging this green-centric perspective. This work suggests that alien life might not be green at all, but rather a spectrum of other colors, with purple emerging as a particularly strong contender.

If a planet's primary photosynthetic life forms were purple (meaning they absorb green light and reflect/transmit red and blue), the evolution of other life, including animals and insects, would be fascinatingly different from Earth.

Here's how other life might be possible and how they could evolve:

1. The Food Web Foundation: Purple Primary Producers

- **Purple "Plants" (or Plant-Analogues):**

Instead of lush green forests and fields, you'd see vast expanses of purple, magenta, or reddish-brown "vegetation". These organisms would be the base of the food web, converting stellar energy into biomass. Their internal chemistry would be based on biopigments like retinal or bacteriorhodophylls, optimized for the available light spectrum.

- **Energy Efficiency & Byproducts:** If these purple photosynthesizers were less efficient than Earth's chlorophyll-based life (as some purple Earth hypotheses suggest), it might impact the overall biomass production and, consequently, the density and size of higher life forms. If they produce different byproducts (e.g., less or no oxygen), that would profoundly shape the atmosphere and subsequent evolution.

2. The Evolution of "Animals" (Herbivores, Carnivores, Omnivores):



- **Color Vision:** The most significant evolutionary pressure for "animals" would be adapting their vision. Herbivores would likely evolve eyes highly sensitive to **purple light**, as this is the dominant wavelength reflected by their primary food source (the purple photosynthesizers). This would be their equivalent of our "green vision" for finding foliage. Alternatively, they might develop sensitivity to other wavelengths (like green, red, or blue) to detect specific, nutrient-rich parts of the plants that reflect these contrasting colors, or to perceive subtle metabolic signals. Predators, meanwhile, might evolve broader spectrum vision to detect their prey against varied backgrounds. Communication (mating displays, warning coloration) would also utilize the available reflected light. Imagine animals with iridescent blue or red patterns; these colors would stand out vividly because they are **absorbed by the purple "plants,"** creating strong contrast against the pervasive purple environment.
- **Digestive Systems:** Their digestive systems would evolve to break down the specific biochemistries of the purple primary producers. This might involve different enzymes or gut microbiomes than Earth-based herbivores.
- **Camouflage:** Animals would evolve camouflage patterns that blend with the purple and blue/red hues of their environment. Think striped or mottled purple, blue, and red patterns for blending into the "foliage."
- **Behavioral Adaptations:**
    - **Light-seeking/avoiding:** Animals might evolve behaviors related to seeking out or avoiding areas with specific light conditions, just as Earth animals do.
    - **Thermoregulation:** The light spectrum available could influence how well organisms absorb or reflect heat, leading to adaptations for thermoregulation.

3. The Evolution of "Insects" (or Insect-Analogues):



- **Pollination and Co-evolution:** If the purple "plants" reproduce via pollination, "insects" would evolve to facilitate this, developing sensory organs (antennae, specialized eyes) tuned to the purple spectrum and nectar/pollen rewards. The "flowers" of these plants would likely be colors that contrast sharply with the purple foliage to attract pollinators – perhaps bright yellow or orange if those pigments are chemically feasible.
- **Herbivory:** Just like Earth's insects, many would evolve as herbivores, consuming the purple plant matter. Their mouthparts and digestive systems would adapt accordingly.
- **Predation:** Other insects would be predators of smaller creatures, with adaptations for hunting in a purple-dominated visual environment.
- **Sensing and Communication:** Communication among insects would also be influenced by the available light. Pheromones and sound might play a more significant role if visual signals are limited in certain conditions.
- **Exoskeletons:** The fundamental structure of exoskeletons might remain similar, as it's an effective way to support and protect small bodies. Their coloration, however, would mirror the environmental hues.

4. Spiders:

In a world with purple photosynthetic life, the size of spiders would largely depend on the atmospheric composition, particularly the oxygen levels, and the efficiency of the primary producers.

- If the purple photosynthesis is efficient and produces oxygen, similar to Earth's oxygenic photosynthesis, then higher oxygen levels could potentially allow for larger spiders, as oxygen is crucial for the high energy demands of larger, more mobile creatures.

- Conversely, if the purple photosynthesis is anoxygenic (does not produce oxygen), or if the overall biomass production is less efficient, then spiders might be smaller due to lower energy availability and different metabolic pathways.
- Planetary gravity would also play a role, with lower gravity potentially allowing for larger body plans.

Visually, these spiders would likely exhibit camouflage patterns blending with the purple, blue, and red hues of their environment. Their eyes would be adapted to the specific light spectrum, possibly tuned to the purple spectrum, and they might display iridescent blue or red patterns for communication or display. Conversely, if the conditions allow for abundant biomass, or if the planet has lower gravity, spiders could potentially be larger.

5. The Role of Bioluminescence:

In an environment where specific light wavelengths are absorbed or reflected, bioluminescence could become a critical form of communication (e.g., for mating displays, warning signals) or a tool for predation in low-light conditions. Different bioluminescent colors might evolve based on the visual capabilities of other life forms, creating stunning light shows in the purple twilight.

6. Other Symbiotic Relationships:

Beyond pollination, other symbiotic relationships would undoubtedly emerge. Imagine mutualistic relationships where "animals" help spread spores or seeds in exchange for vital nutrients, or commensal relationships where one organism benefits without harming the purple flora, perhaps sheltering within their unique structures.

7. Enhanced Sound and Chemical Communication:

While visual signals are powerful, the unique light conditions of a purple world might lead to a greater reliance on other forms of communication. Sound, through elaborate calls or vibrations, and chemical signals, like complex pheromones, could become even more developed and intricate methods for communication among both animals and insects, especially in dense "vegetation" or at night.

8. Key Environmental Considerations and Their Impact on Evolution:

- **Atmospheric Composition:** If purple photosynthesis (e.g., retinal-based) does *not* produce oxygen as a byproduct (anoxygenic photosynthesis), the atmosphere would be profoundly different. Higher life forms would need to be anaerobic or have different metabolic pathways. This would drastically change the type of complex life possible, as oxygen is crucial for the high energy demands of large, mobile animals on Earth. If a purple pigment *can* perform oxygenic photosynthesis, then oxygen could accumulate, paving the way for aerobic respiration and more complex, energetic life, similar to Earth's trajectory after the Great Oxidation Event.
- **Stellar Spectrum:** The color of the star itself is paramount. If the star emits more red light, then purple life forms are a logical adaptation. This would influence the overall light levels and temperature, driving further evolutionary paths. Red dwarf stars are cooler than our Sun and emit most of their light in the red and infrared parts of the spectrum. They emit very little blue or green light.
    - Here's is the reasoning for why purple life might be a logical adaptation around a red dwarf: If a star emits most of its light in the red and infrared, then photosynthetic organisms would evolve pigments that are most efficient at absorbing those

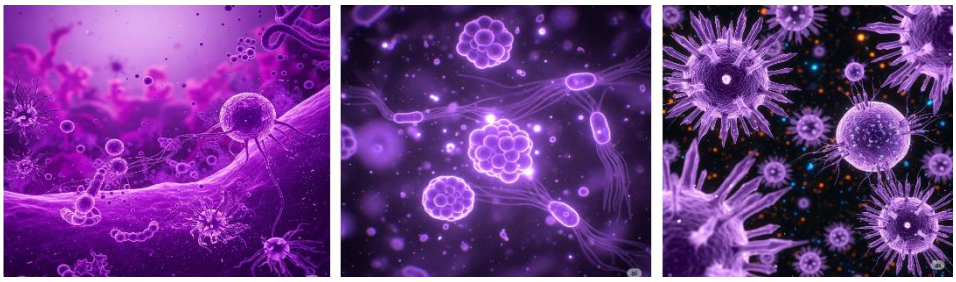
wavelengths. Chlorophyll (which makes Earth plants green) primarily absorbs blue and red light, reflecting green. This works well for a Sun-like star that emits a broad spectrum of visible light. Purple pigments (like retinal or bacteriorhodopsins) tend to absorb green and yellow light, reflecting red and blue (which combine to look purple). Therefore, on a planet orbiting a red dwarf star (which emits primarily red/infrared light, but still *some* green and yellow), organisms might evolve purple pigments to capture the green and yellow light that the red dwarf *does* emit, as that would be the most available light for absorption that isn't already abundant in red/infrared. In this scenario, they would be filling a "niche" in the spectrum that isn't dominated by the star's strongest emission.

    - In essence, the logic is: Red dwarf stars = lots of red/infrared light, less green/blue light. Purple pigments = absorb green/yellow light, reflect red/blue. Therefore, if a red dwarf system's light is mostly red, a purple pigment that absorbs the *less common* but still present green/yellow light could be an efficient strategy for photosynthesis, allowing the organism to utilize a part of the spectrum that isn't "overcrowded" by the star's peak output, and potentially reflecting the very abundant red light.
- **Planetary Composition:** The geological makeup of the planet would affect nutrient availability, mineral composition, and potential toxic elements, all of which would shape life's biochemistry and evolution.
- **Gravity:** Lower or higher gravity would affect body plans, locomotion, and the size limits of creatures.
- **Water Availability:** The presence and distribution of liquid water are crucial for all known life (life as we are familiar with). In the future I will be writing about alternate solvents and the possible microbes, plants, animals and insects that may be able to evolve.
- **Adaptations for Extreme Environments:** Consider how purple life might adapt to harsh conditions like extreme temperatures, strong tidal forces, or active volcanism. Organisms might evolve specialized pigments for thermoregulation or even thrive through chemosynthesis in the absence of sufficient stellar energy.

9. The Sunrise and "Purple Sunset" Phenomenon:

Just as Earth's atmosphere scatters blue light to create red sunsets, a purple world with an atmosphere shaped by purple photosynthesizers could experience unique atmospheric phenomena. Imagine sunsets and sunrises painted in hues of green and yellow, depending on the scattering properties of the atmosphere, creating a truly alien aesthetic that influences the behavior of nocturnal or crepuscular creatures.

9. The Unseen World: Microbial Life and Decomposers:



While we often focus on larger life forms, the microbial world is the unseen engine of any ecosystem. Decomposers and other microorganisms would play a vital role in nutrient cycling, breaking down the unique biochemistries of purple life. Their adaptations would be just as fascinating, influencing the very foundation of the purple world's ecology.

Endless Canvas of Evolution: Concluding Our Purple Journey

As we've explored the hypothetical "purple world," it becomes brilliantly clear that while the specifics of life might diverge wildly from our Earthly experiences, the fundamental engines of **evolution—natural selection, adaptation, and co-evolution**—remain universal. Environmental pressures, particularly the unique light spectrum and atmospheric composition of such a planet, wouldn't just tweak existing life forms; they would sculpt entirely new ones.

From fauna cloaked in **purple camouflage** to herbivores with **green-tuned eyes** for discerning sustenance, and from creatures with **novel respiratory systems** to those relying on **unique biochemical pathways** to process alien nutrients, every adaptation is a testament to life's incredible plasticity. Even in the absence of familiar visual cues, methods like **bioluminescent displays** and **highly evolved sound and chemical communication** would flourish, creating complex societies beyond our current comprehension.

This thought experiment into a "purple world" isn't just about imagining fantastical creatures; it's about expanding our understanding of life's boundless potential. It serves as a powerful reminder that if life exists elsewhere, it will undoubtedly be shaped by its environment in ways we can barely conceive, sparking imaginative and scientifically grounded considerations about what alien life could truly look like!