# Melanin Inspired Solutions for Transformative Transportation

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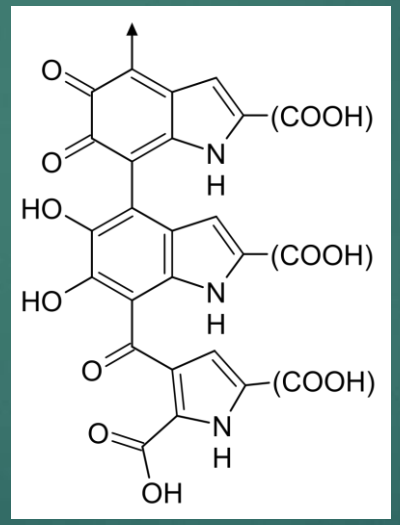
Transportation is evolving
towards intelligent vehicles
with hybrid and electric propulsion

# Melanin's refer to a broad class of functional bio-macromolecules

Melanins have traditionally been known as a pigment.

Melanins have a broad range of properties.

- **Broadband absorbance**
- **Energy harvesting**
- **Free radical scavenging**
- **Structural enhancement**
- **Hygroscopic**
- **Durable**
- **Chemical inertness**
- **High thermal conductivity**

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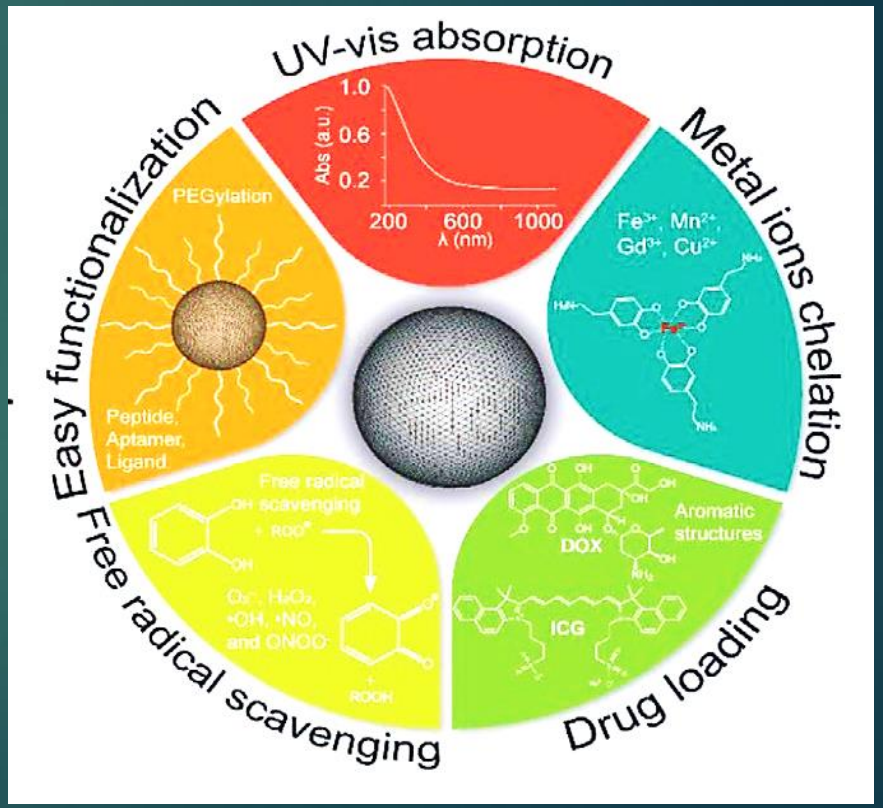
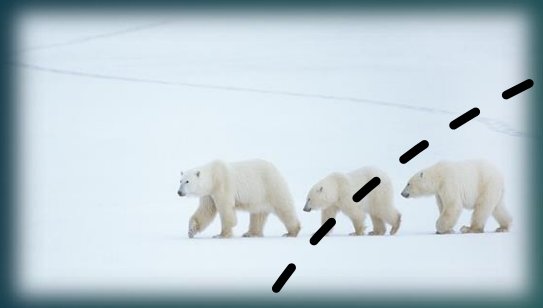
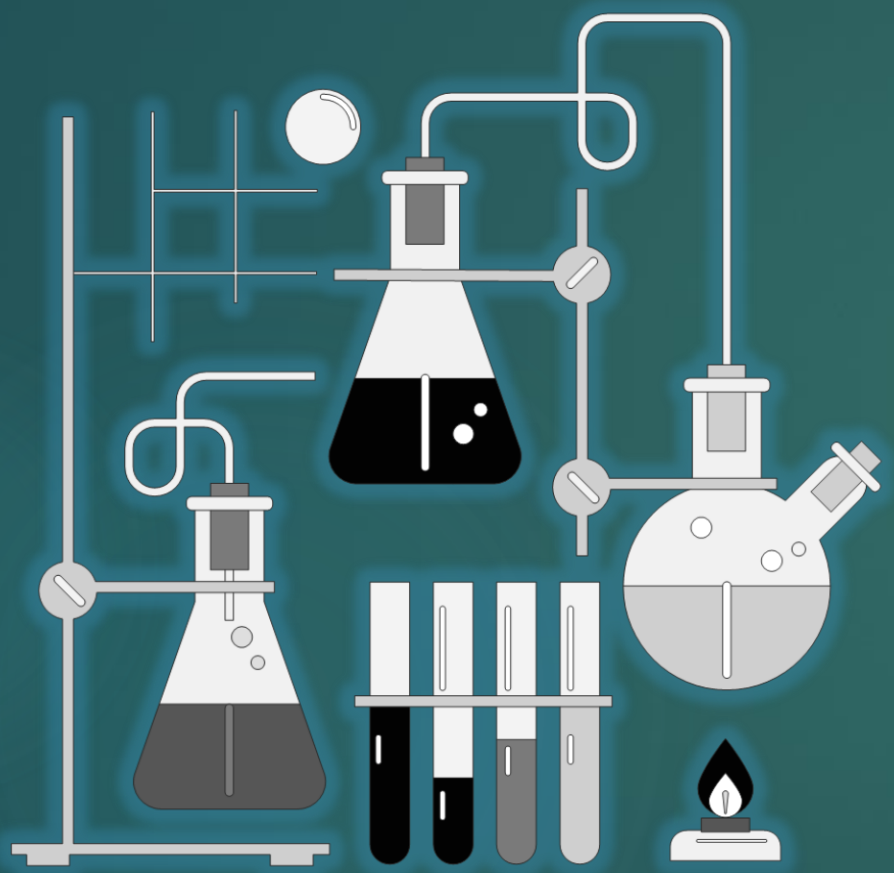


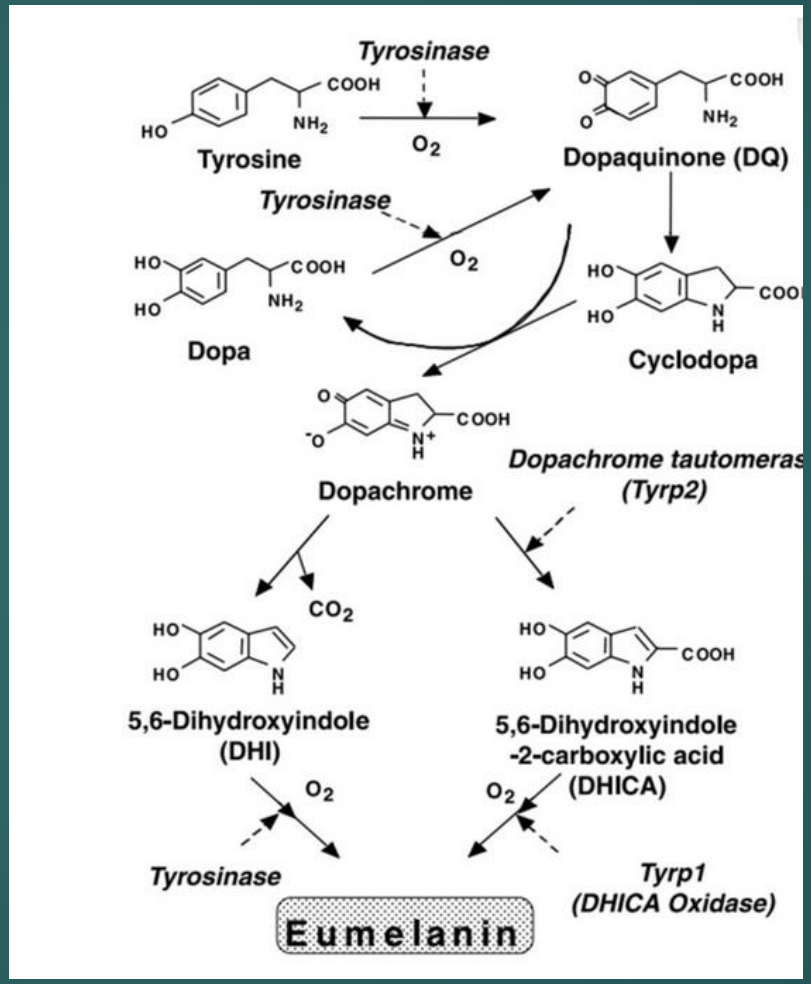

From: Liu, Heng, et al (2020) https://creativecommons.org/licenses/by/4.0/



**Melanin is ubiquitous throughout the biosphere**

# Melanin can also be produced synthetically






From: Mostert, A Bernardus, (2021)

# Scopus®

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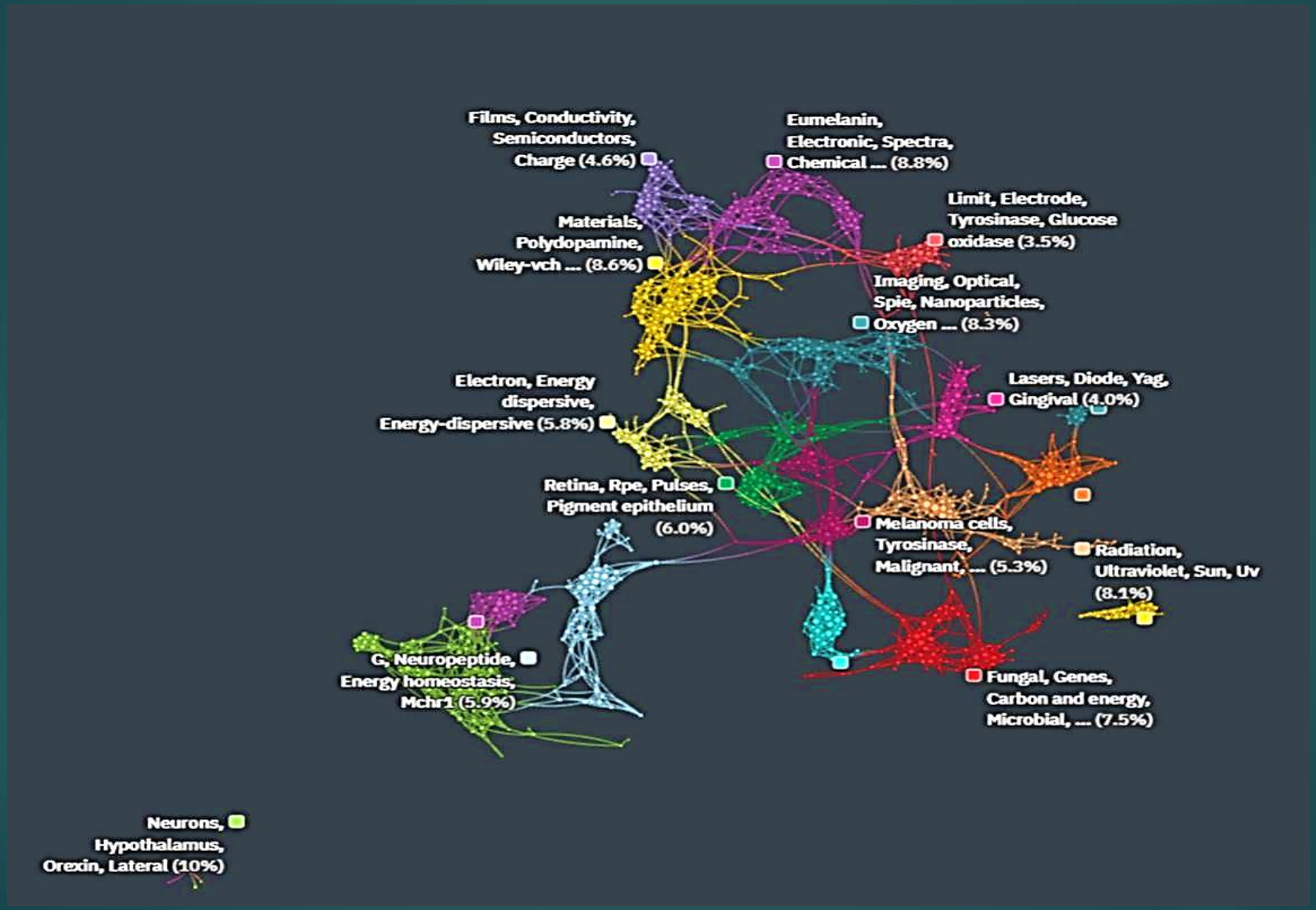
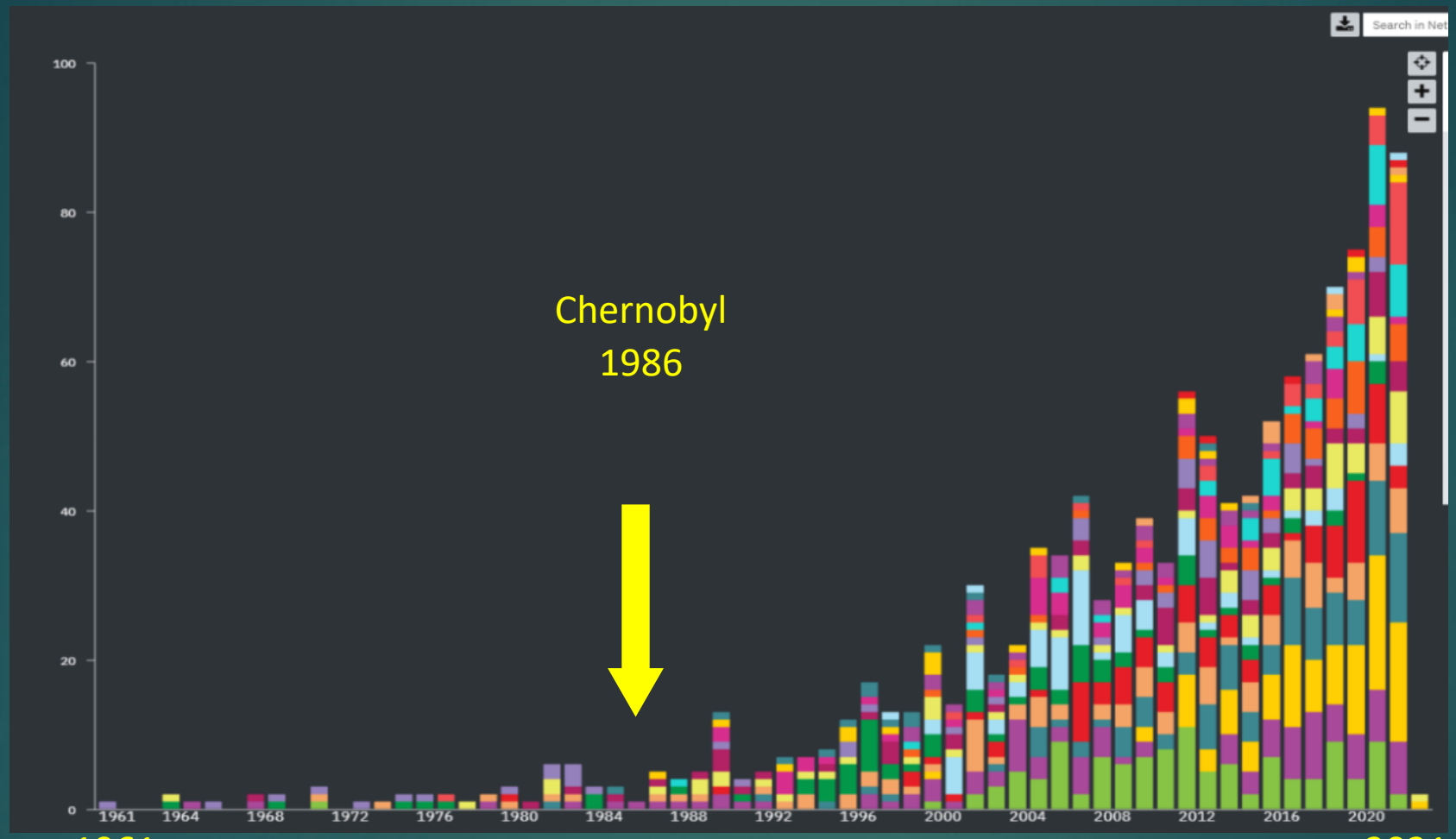


# The accident that started it all




Non-medical Melanin Publication Data

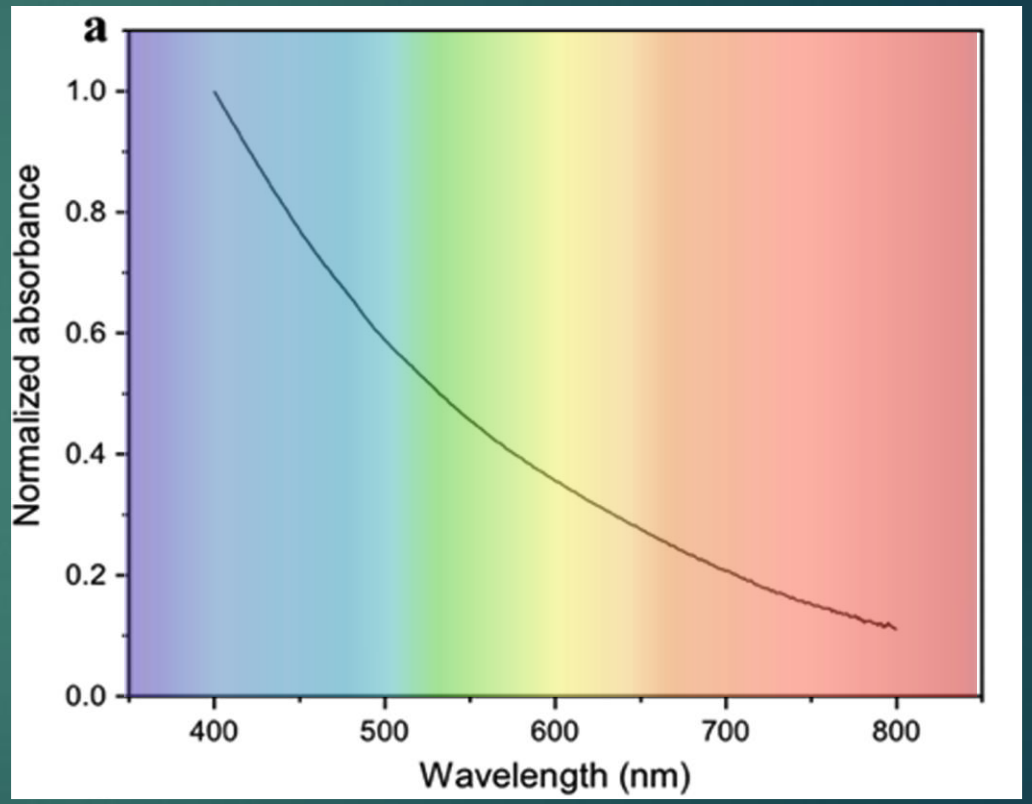
# Melanin Properties and Applications

# Broad Band Absorption

Melanin absorbs from the UV through the entirety of the visible spectrum.

## Applications

- **Photoprotection**
  - **UV stabilized polymers**
    - Paulin, V., Graeff, C.(2021)
  - **UV absorber**
    - Liang, Y. 2018
- **Thermal regulation**
  - K of $5.0323 \times 10^{-3}$ J/cm/K/s
    - Kim, Do-Hyun (2011)
- **Melanin based electronic materials**
  - **Conductors**
    - Migliaccio, Ludovico, et al., (2019)
  - **Thin film transistors**
    - Bothma, P., et al. (2008)
  - **Sensors**
    - Zhang, Xiaoling, et al., (2021)




Adapted From: Xu, Ri, et al., *ACS omega* 4.7 (2019): 12244-12251.

(https://pubs.acs.org/page/policy/authorchoice_termsofuse.html

# Energy Harvesting Applications

Melanin has been shown to absorb radiation and transform that energy to other forms.


- Zhdanova, Nelli N, et al. (2000): 1421-26.
- Dadachova, Ekaterina, and Arturo Casadevall. (2008): 525-31.
- Wei Cao, et al. (2020)

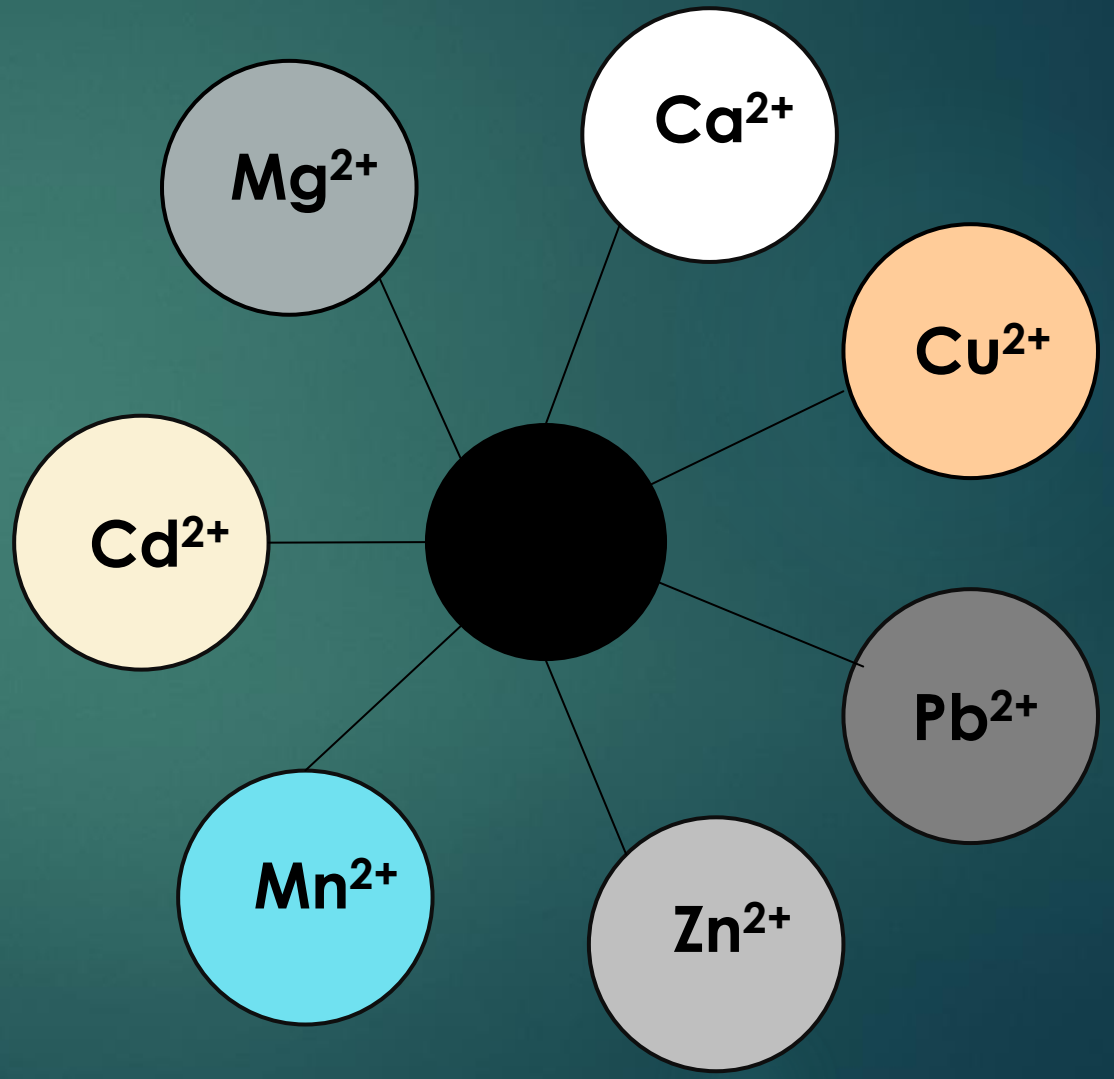

Artur Korneev, Deputy Director of Shelter Object, viewing the "elephants foot" lava flow, Chornobyl NPP. Photographer: unknown. Fall 1986."

# Melanin enhanced materials

**Applications**

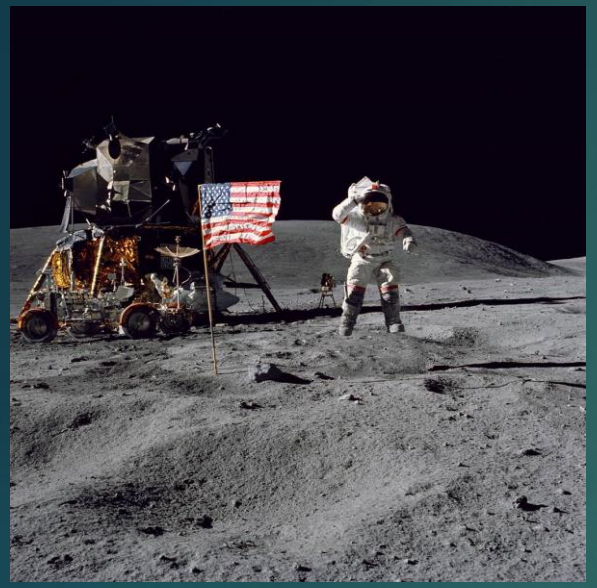
- **Li-ion battery technology**
  - Shembel, E., et al. .(2020)
  - Kong, J. et al. (2012)
- **Supercapacitors**
  - Paulin, V. ,Graeff C. (2021)
- **Piezoelectric sensors**
  - Huang S. el al. (2007)
- **Anti fungal paint additives by Melanin-mediated synthesis of silver and gold Nanoparticles**
  - Apte, Mugdha, et al. (2013)

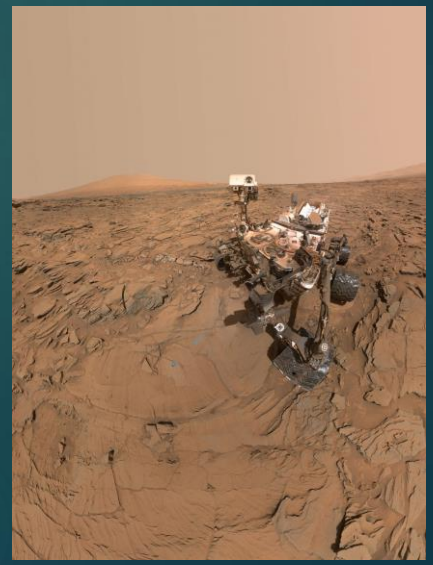
Melanin has a high affinity for metal ions



# Protection for Space travel

Cordero, R., et al., (2017)



# The Big Picture


# Bibliography


- By Roland Mattern - Roland1952, Public Domain, https://commons.wikimedia.org/w/index.php?curid=6943464
- Liu, Heng, et al. "Melanin-Like Nanomaterials for Advanced Biomedical Applications: A Versatile Platform with Extraordinary Promise." *Advanced Science* 7.7 (2020): 1903129.
- Mostert, A. Bernardus. "Melanin, the what, the why and the how: An introductory review for materials scientists interested in flexible and versatile polymers." *Polymers* 13.10 (2021): 1670.
- Paulin, João Vitor, and Carlos FO Graeff. "From nature to organic (bio) electronics: a review on a melanin-inspired material." *Journal of Materials Chemistry C* (2021).
- Liang, Yujia. *UV protective properties and applications of melanin and melanin-based materials*. Diss. Deakin University, 2018.
- Kim, Do-Hyun. "Using a melanin granule lattice model to study the thermal effects of pulsed and scanning light irradiations through a measurement aperture." *Journal of Biomedical Optics* 16.12 (2011): 125002.
- Migliaccio, Ludovico, et al. "Evidence of unprecedented high electronic conductivity in mammalian pigment based eumelanin thin films after thermal annealing in vacuum." *Frontiers in chemistry* 7 (2019): 162.
- Bothma, Jacques P., et al. "Device-quality electrically conducting melanin thin films." *Advanced Materials* 20.18 (2008): 3539-3542.
- Zhang, Xiaoling, et al. "Melanin-inspired conductive hydrogel sensors with ultrahigh stretchable, self-healing, and photothermal capacities." *ACS Applied Polymer Materials* 3.4 (2021): 1899-1911.
- Xu, Ri, et al. "Melanin: a greener route to enhance energy storage under solar light." *ACS omega* 4.7 (2019): 12244-12251.
- Cordero, Radames JB, Raghav Vij, and Arturo Casadevall. "Microbial melanins for radioprotection and bioremediation." *Microbial Biotechnology* 10.5 (2017): 1186.
- Zhdanova, N. N., et al. "Destruction of radioactive particles by strains of Cladosporium cladosporoides (FRES.) de Vries." *Mikrobiolohichnyi Zhurnal (Kiev, Ukraine: 1993)* 64.6 (2002): 47-56.
- Dadachova, Ekaterina, and Arturo Casadevall. "Ionizing Radiation: How Fungi Cope, Adapt, and Exploit with the Help of Melanin." *Current opinion in microbiology* 11.6 (2008): 525-31. Print.
- Cao, Wei, et al. "Radical-Enriched Artificial Melanin." *Chemistry of Materials* 32.13 (2020): 5759-5767.
- Shembel, Elena, et al. "Melanin as Semiconductor with Polymer Structure is Effective Modifier for Electrodes of High-Energy Li-Ion Batteries." *ECS Transactions* 99.1 (2020): 47.
- Kong, Junhua, et al. "Highly electrically conductive layered carbon derived from polydopamine and its functions in SnO 2-based lithium ion battery anodes." *Chemical Communications* 48.83 (2012): 10316-10318.
- Apte, Mugdha, et al. "3, 4-dihydroxy-L-phenylalanine-derived melanin from Yarrowia lipolytica mediates the synthesis of silver and gold nanostructures." *Journal of Nanobiotechnology* 11.1 (2013): 1-9.