Bioplastics

Discussing strengths and weaknesses in Socratic Circles

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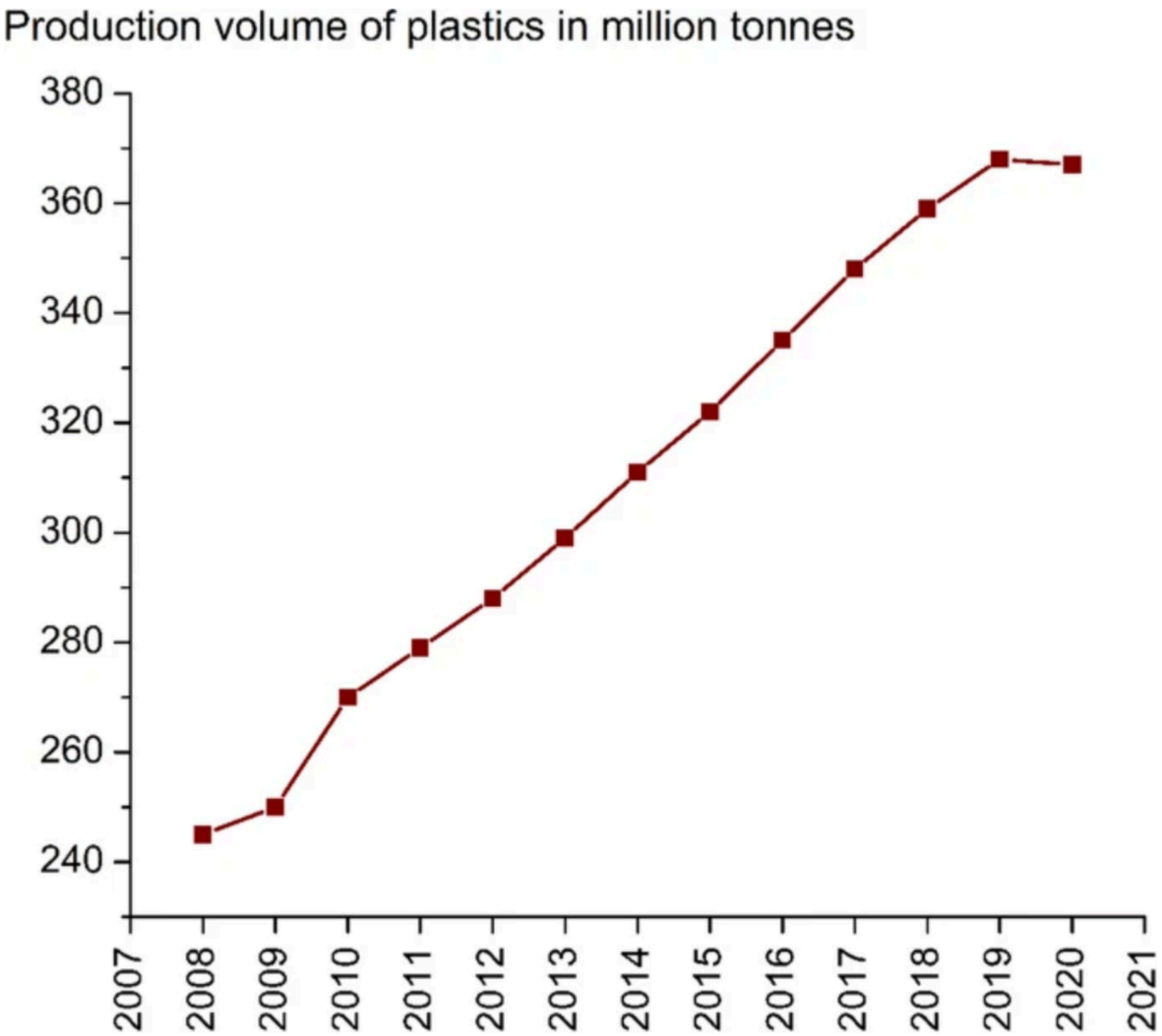
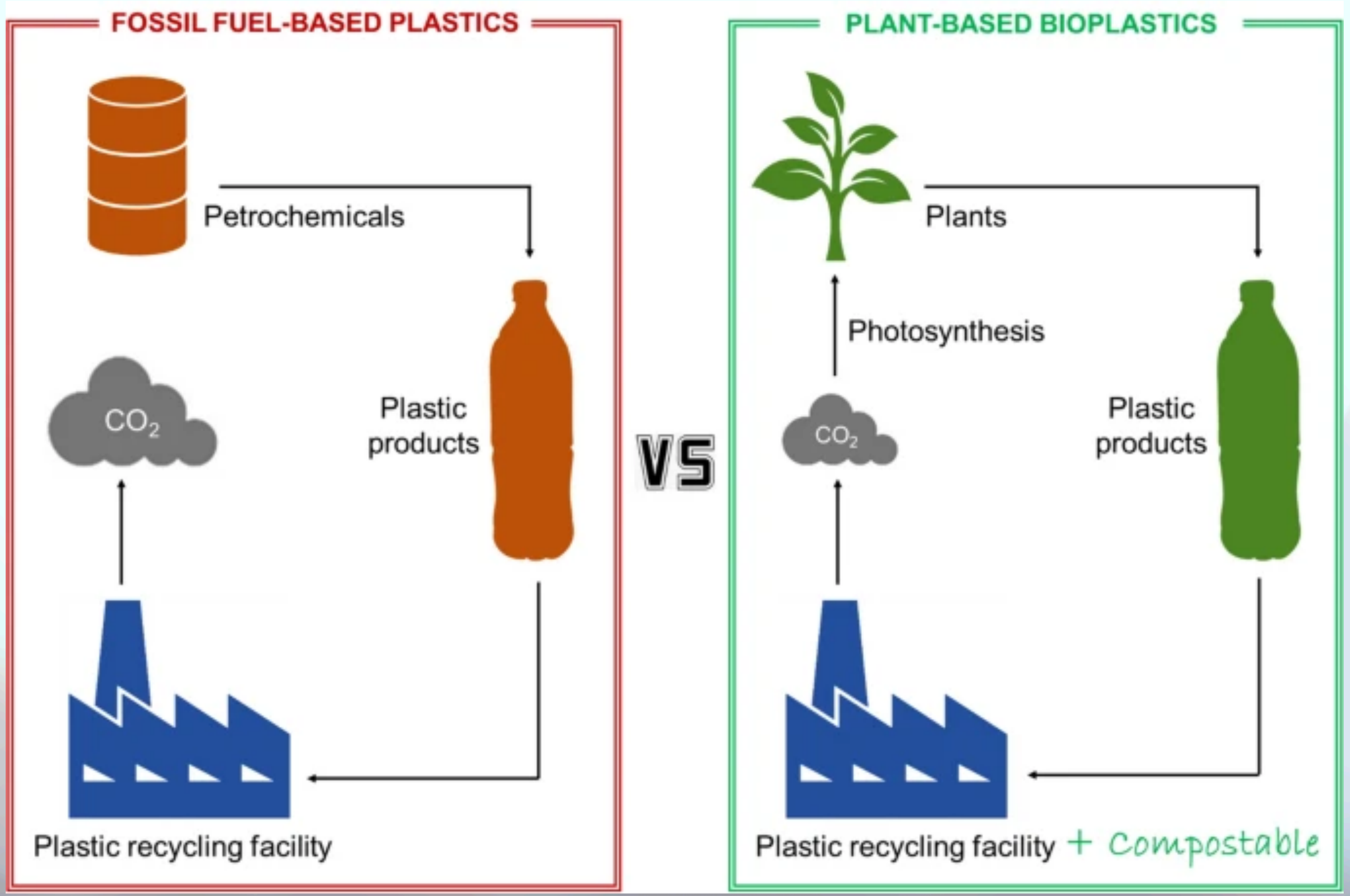
Production volume of plastics in million tonnes

Fig. 1



source: Statista 2020). The production of plastics in 2020 has increased by 36% since 2010. There was a slight decline in plastics production in 2020 because of the unprecedented impacts of the COVID-19 pandemic on the world economy

Global production of plastics (Data


FOSSIL FUEL-BASED PLASTICS
Petrochemicals
Plastic products
CO_2
Plastic recycling facility
VS
PLANT-BASED BIOPLASTICS
Plants
Photosynthesis
Plastic products
CO_2
Plastic recycling facility + Compostable

Introducing Bioplastics

Friend or Foe?

- commercial plastics are made from **fossil resources**

- bio-plastics can also be made from **renewable** resources with monomers are extracted or synthesized from biomass compounds (such as sugars in plants) and then polymerized to either make a direct replacement for an existing plastic, such as polyethylene (PE), or novel polymers, such as polyhydroxyalkanoates (PHAs). Biomass extraction can also yield non-synthetic natural polymers, such as starch, natural rubber and proteins.

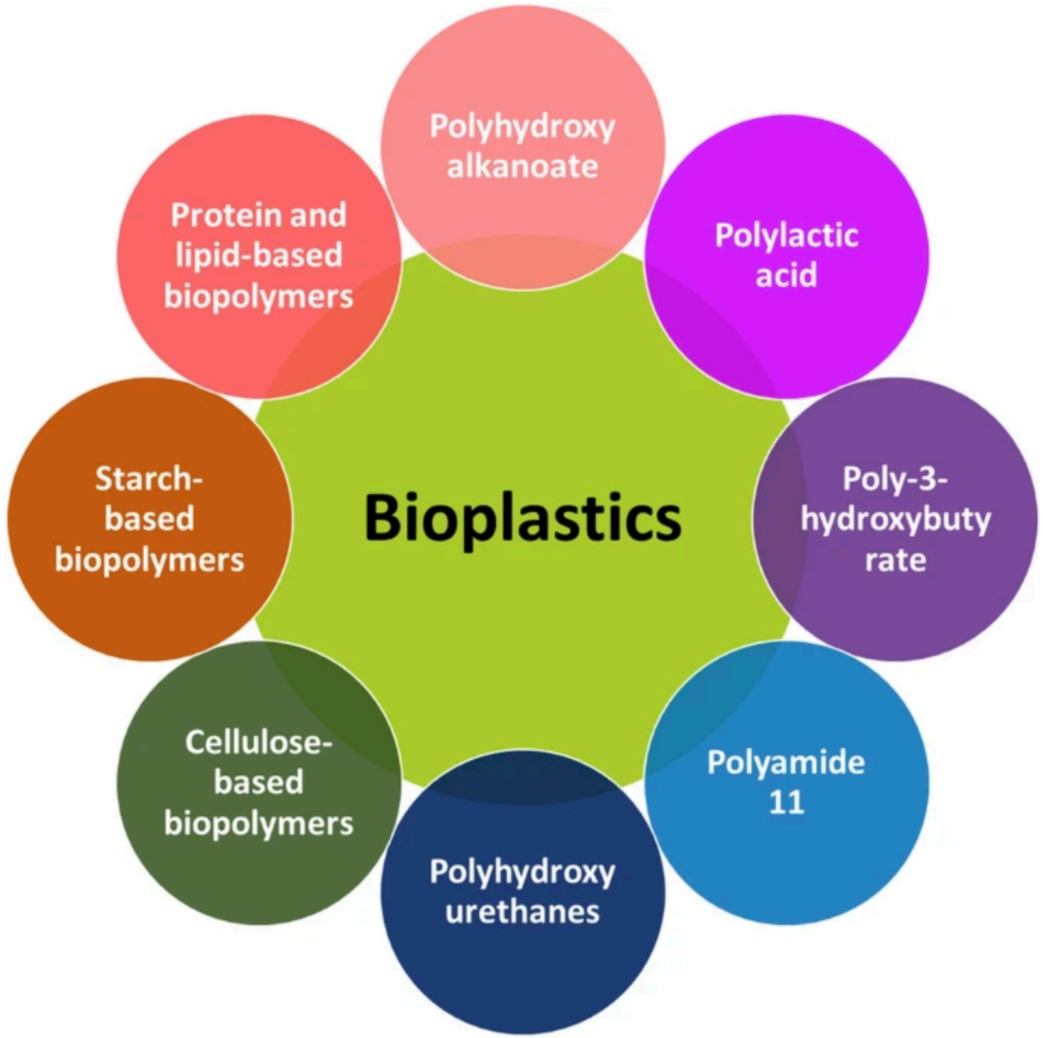
What does bioplastic mean?

Are biodegradable fossil fuels classed as bioplastics?

- plastics made from renewable resources (‘bio-based’) or
- biodegradable or
- made through biological processes or
- a combination of these
- Ambiguity of definition [Some biodegradable but fossil-based plastics are also referred to as bioplastics; however, the use of this terminology is advised against, as it is misleading]

Commonly used Bioplastics

Fig. 3



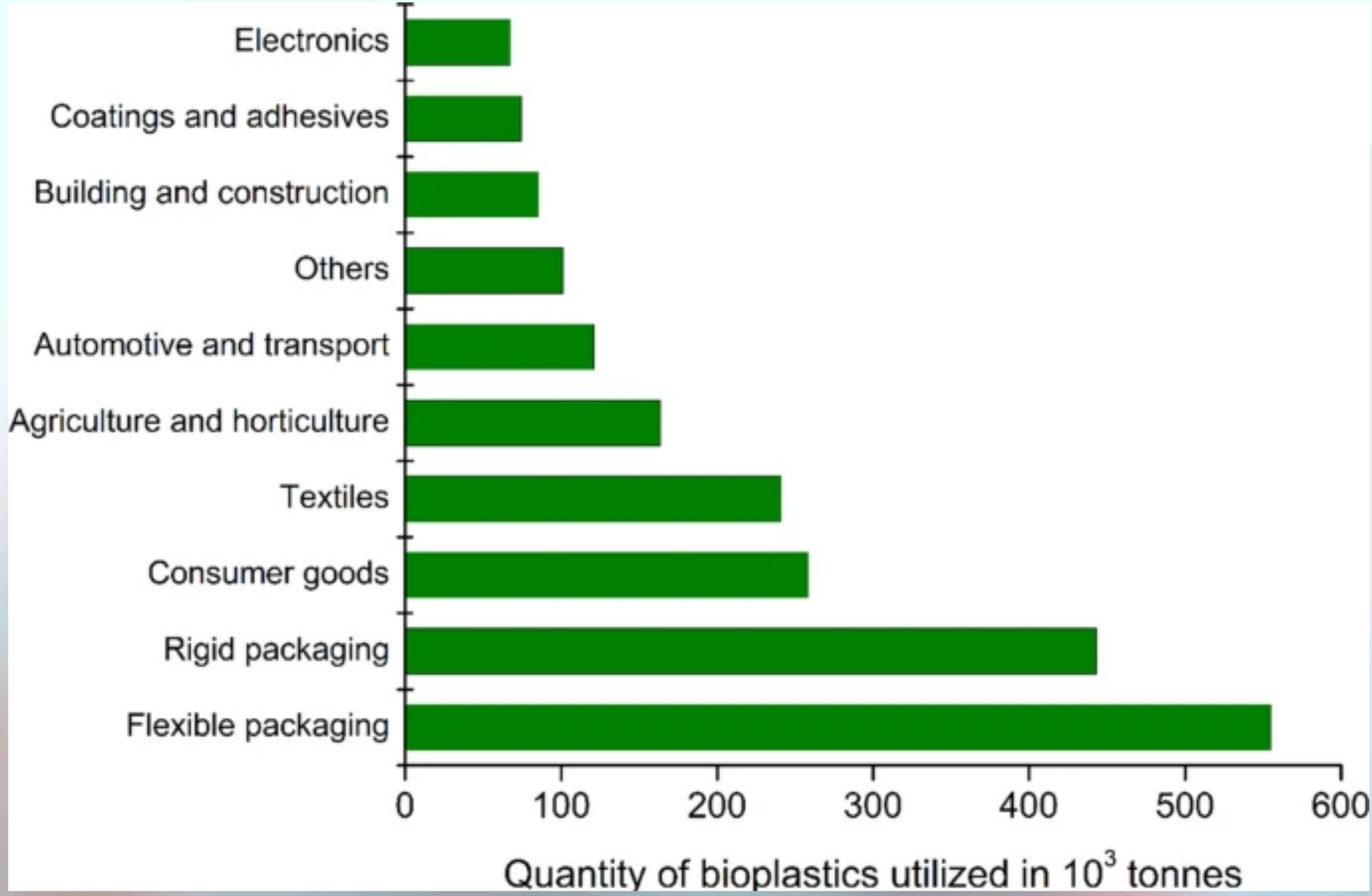
Commonly used bioplastic polymers. Some most popular bioplastic polymers today are produced from polyhydroxyalkanoate, polylactic acid, poly-3-hydroxybutyrate, polyamide 11, polyhydroxyurethanes, cellulose, starch, proteins and lipids

(Adapted from Arikan and Ozsoy 2015).

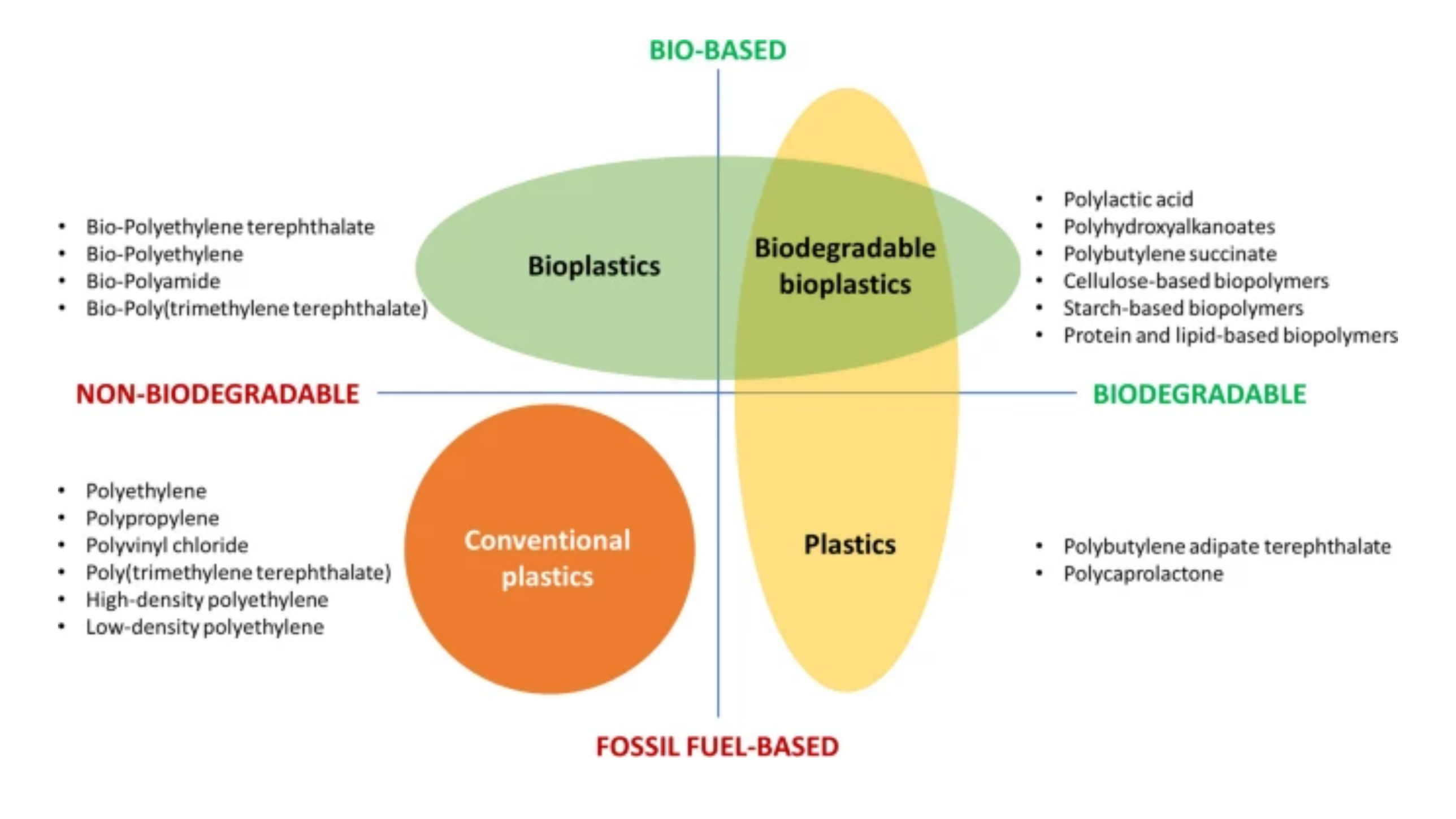
Spectrum for the recommended usage of plastics considering environmental sustainability

Bioplastics are the most preferred followed by polypropylene, polyethylene and polyethylene terephthalate, polyurethane, polycarbonate, polystyrene and acrylonitrile butadiene styrene. Polyvinyl chloride is the least preferred among all plastics considering its contribution to environmental pollution

Bioplastics Applications

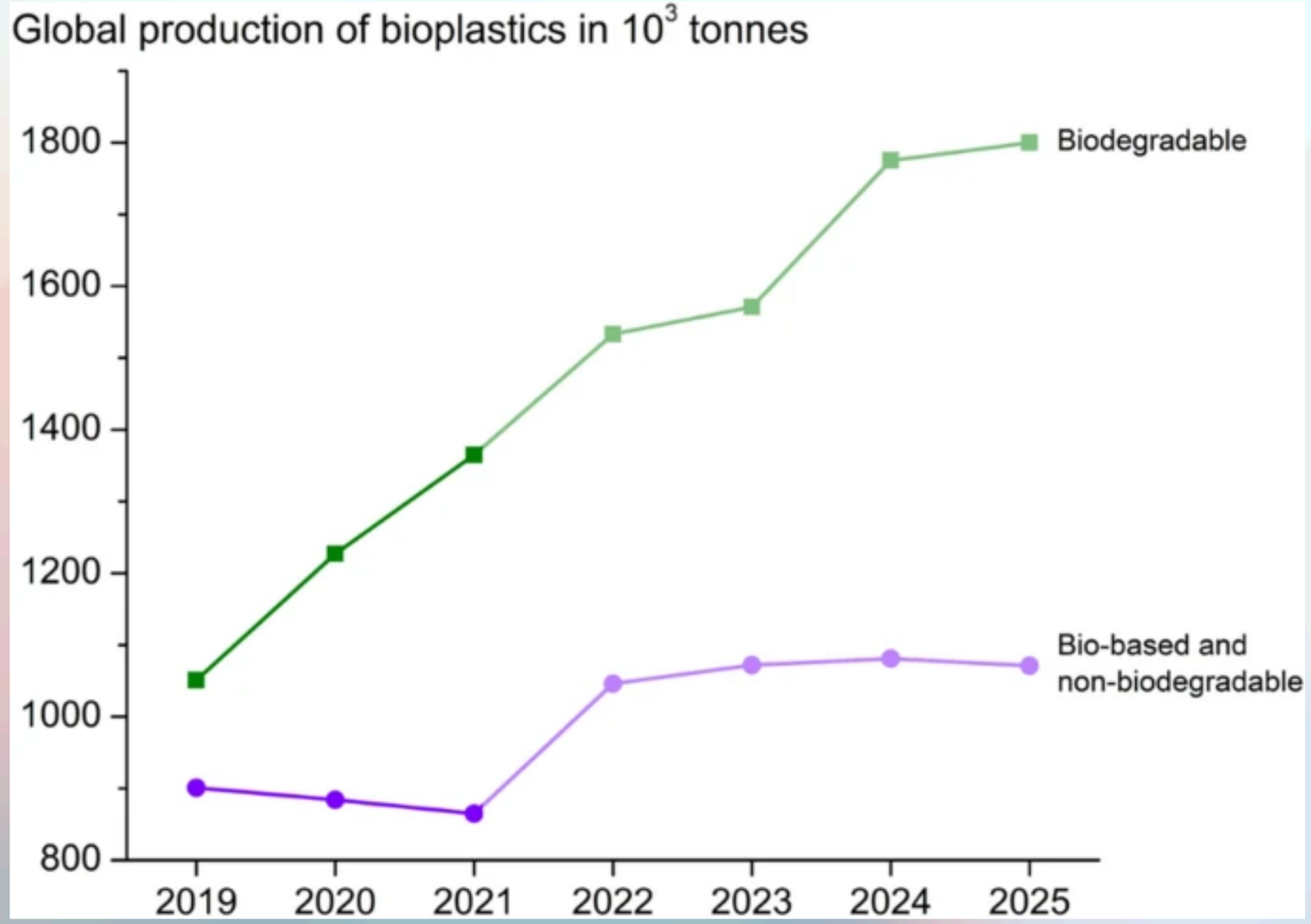


European Bioplastics (2021) Bioplastics market data. https://www.european-bioplastics.org/market/ (accessed on 2 August 2021)


BIO-BASED
Bioplastics
Biodegradable bioplastics
Bio-Polyethylene terephthalate
Bio-Polyethylene
Bio-Polyamide
Bio-Poly(trimethylene terephthalate)
Polylactic acid
Polyhydroxyalkanoates
Polybutylene succinate
Cellulose-based biopolymers
Starch-based biopolymers
Protein and lipid-based biopolymers
NON-BIODEGRADABLE
BIODEGRADABLE
Conventional plastics
Plastics
Polyethylene
Polypropylene
Polyvinyl chloride
Poly(trimethylene terephthalate)
High-density polyethylene
Low-density polyethylene
Polybutylene adipate terephthalate
Polycaprolactone
FOSSIL FUEL-BASED

Global production of bioplastics

- The worldwide production of biodegradable bioplastics is projected to increase exponentially in the coming years, unlike bio-based non-biodegradable plastics that indicate a stationary growth pattern



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Socratic Circles

Form an inner and outer circle. The inner circle has one empty seat.

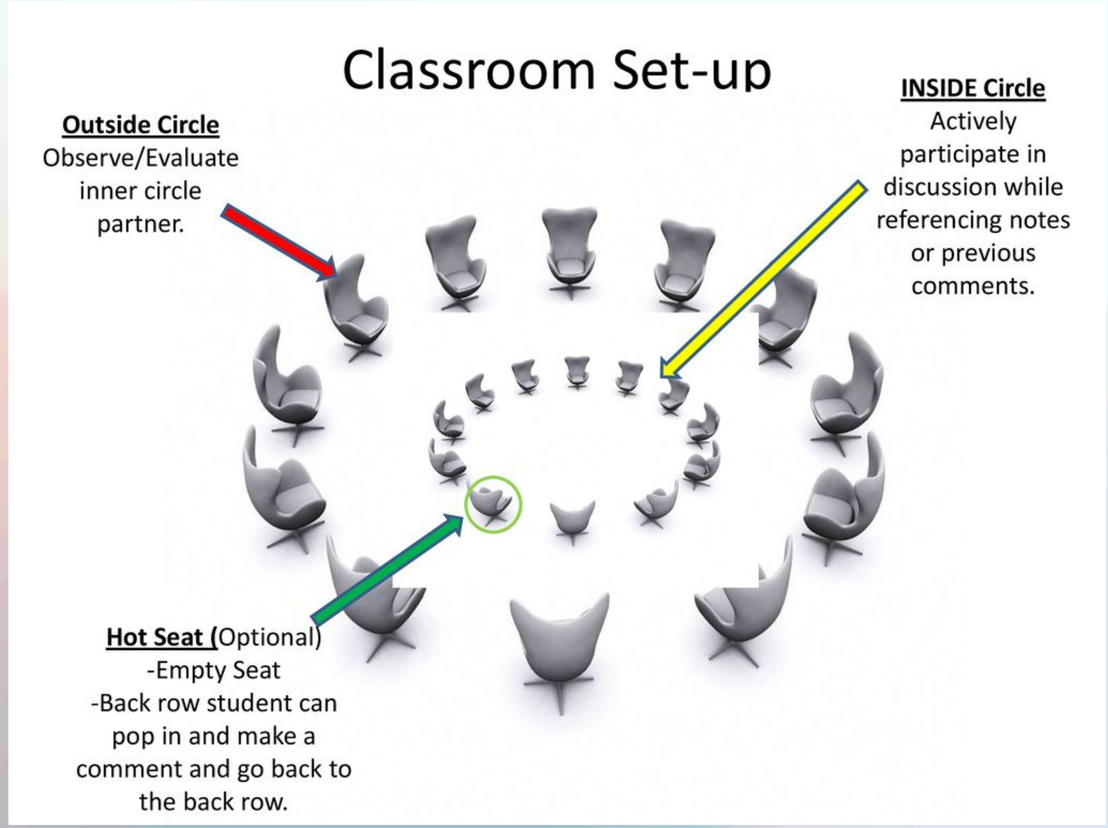
All students read the two articles and annotate key points

Students in the inner circle discuss the issues / questions posed

Students in the outer circle observe and take notes.

Students in the outer then share observations and reflections

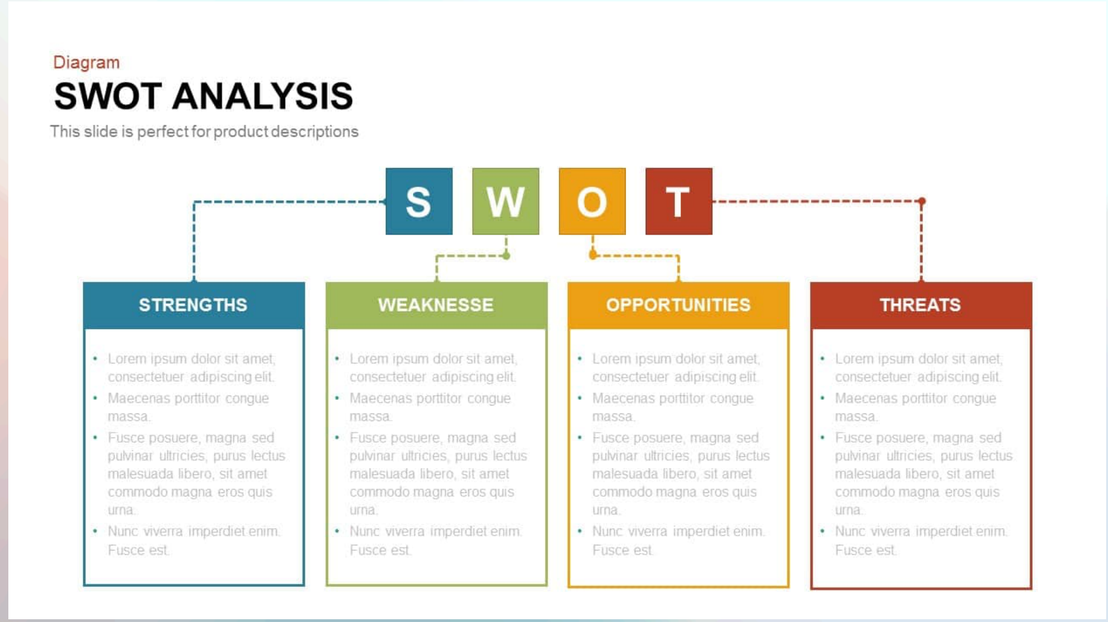
Students in the outer circle evaluate inner circle partner.



Homework

If you are an outer circle student, upload your observations and reflections

If you are an inner circle student, make a table with key strengths and weaknesses of bioplastics



Challenges in Bioplastics

Dependency on Crude Oil: Synthetic plastics utilize approximately 4% of global crude oil annually, subjecting production to fluctuating prices and increasing demand.
Energy Efficiency: Bioplastics production requires less energy input compared to synthetic plastics, with 44 MJ/kg of bio-resin needed versus 78–88 MJ/kg for petrochemical-based plastics.
Technical Limitations:
- Intermediate products from bioplastics synthesis can contaminate conventional plastic recycling streams if not separated.
- Current bioplastics primarily use first-generation feedstocks (sugarcane, corn, etc.), raising concerns over competition with food supply and agricultural resources.

Biodegradation Challenges:
- Bioplastics may require controlled conditions for efficient biodegradation, posing challenges for end-of-life disposal.
- Landfilling of biodegradable polymers may not be feasible due to specific biodegradation conditions not met.

Infrastructure and Waste Management:
- Establishment of specific sites for bioplastics disposal requires land space, controlled environments, and capital investment.
- Effective end-of-life remediation necessitates waste sorting, microbial proliferation, and routine monitoring.

Competitive Market Dynamics:
- Bioplastics must compete with conventional plastics in terms of production cost, infrastructure compatibility, waste management, and consumer awareness.

Opportunities and Advancements:
- Advances in biotechnology offer opportunities for developing new bioplastics and engineered biopolymers for diverse industries.

Societal Acceptance and Education:
- Educating communities on bioplastics' usage, environmental impacts, and waste management is crucial for societal acceptance and market growth.
- Enforcement of bylaws promoting bioplastics usage can mitigate environmental problems and boost agricultural economies