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"Harnessing the Planet's Primary Producers"™

Quick Chat: Biofuels – Promising Alternative or a Broken Promise?

LONGHORN ENERGY CLUB

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Monday Jan 29, 2018

Ramjohn, 2018

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Question: Biofuels – Promising Alternative or a Broken Promise?

Short Answer: Yes (think Schrödinger's cat).

Longer answer: Biofuels will become unnecessary and/or irrelevant as technologies such as: electric vehicles, batteries, and renewable energy become widely available, adopted, and cost effective.

Preparing for life in a post-petroleum world

Identify the drivers and alternatives

Let's back up a bit: Why are we interested in biofuels at all?

Short Answer: As an energy source for electricity, heat, transportation, work, etc.

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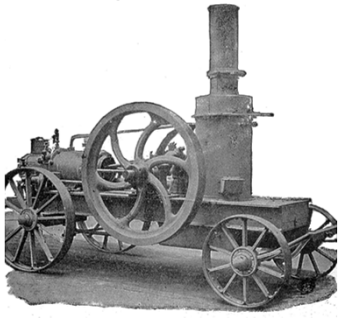
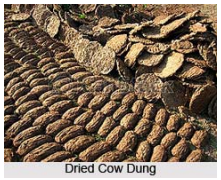
Brief look at energy through history

Humans need energy for: Electricity, Heat, Transportation, Work, etc.





Adapted from: https://www.ucsusa.org/clean_energy/our-energy-choices/a-short-history-of-energy.html#.Wmt1IjdG1PY

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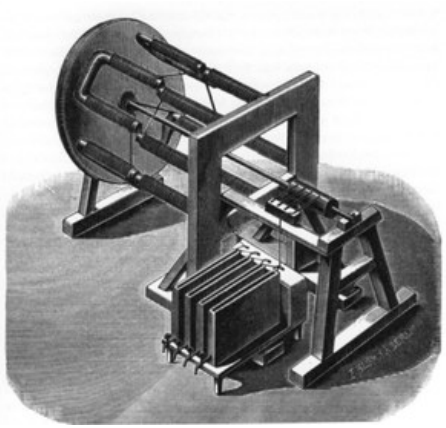
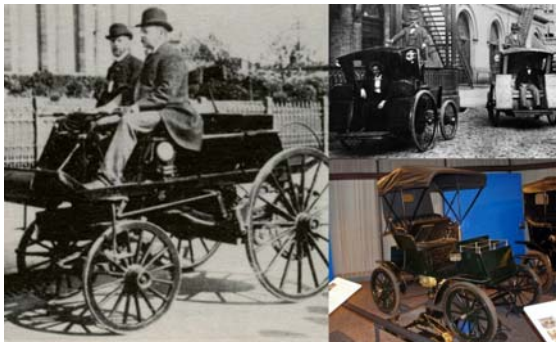
Is renewable energy or the electric motor new?

Worlds first hydro-electric plant (1882) Appleton, Wisconsin
http://www.americaslibrary.gov/jb/gilded/jb_gilded_hydro_1_e.html

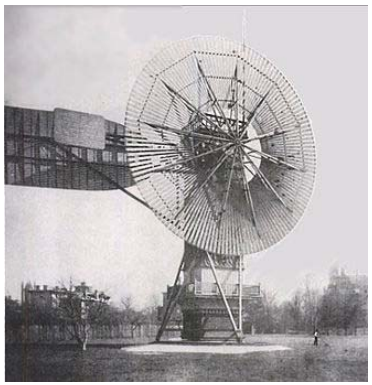


The first real electric motor
Moritz Jacobi, Königsberg, May 1834
https://www.eti.kit.edu/english/1376.php



1830s: Electric cars predated the internal combustion engine.
https://www.caranddriver.com/flipbook/worth-the-watt-a-brief-history-of-the-electric-car-1830-to-present#2

1954: Bell Labs first practical solar cell
http://www.bell-labs.com/timeline/#/1950/1/open/



Charles Brush's windmill of 1888, used for generating electricity.
https://en.wikipedia.org/wiki/History_of_wind_power

Adapted from: https://www.ucsusa.org/clean_energy/our-energy-choices/a-short-history-of-energy.html#.Wmt1IjdG1PY

Identify the drivers and alternatives

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Alternative Discussion: Bioeconomy not Biofuels

If we can transition from fossil hydrocarbons as energy sources to "clean" energy, e.g. renewables (solar, wind, geo, hydro), for heat, electricity, transportation, work, etc…

…then we could focus biorenewable resources on creating a **bioeconomy** to sustainably replace the non-fuel products and services from fossil hydrocarbons in the fossil-based economy.

Renewable Energy + Energy Storage
= No Need for Liquid Fuels

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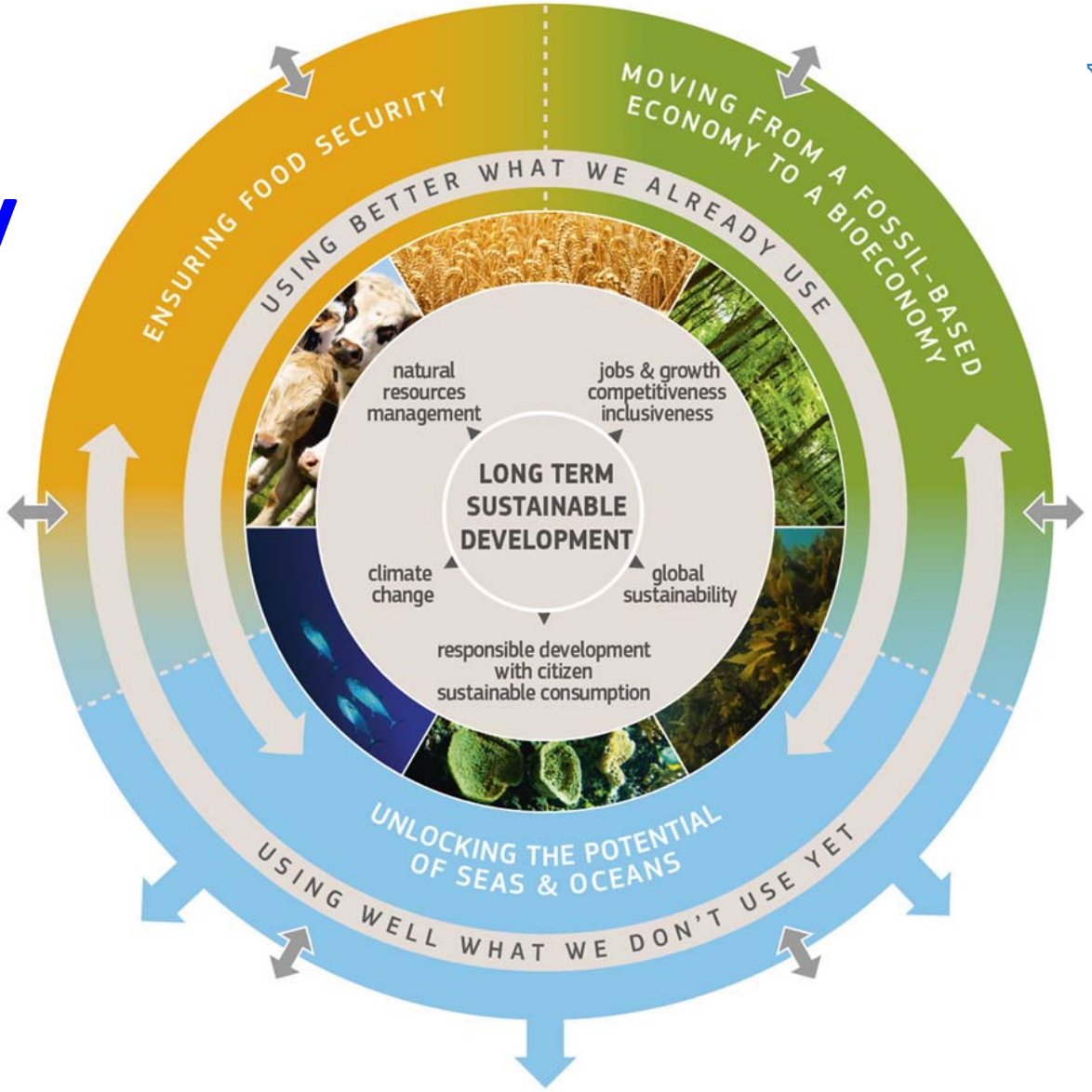
Bioeconomy

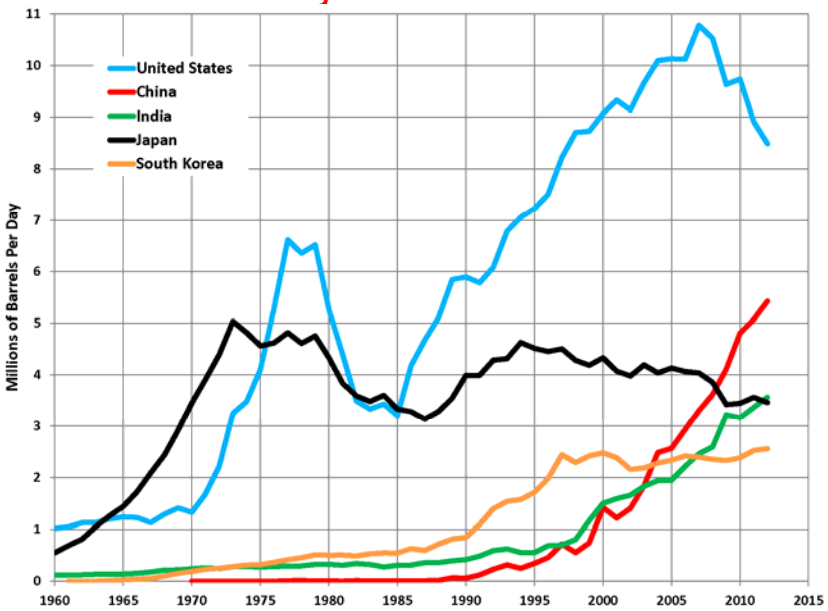
Where do biofuels fit in a bioeconomy?



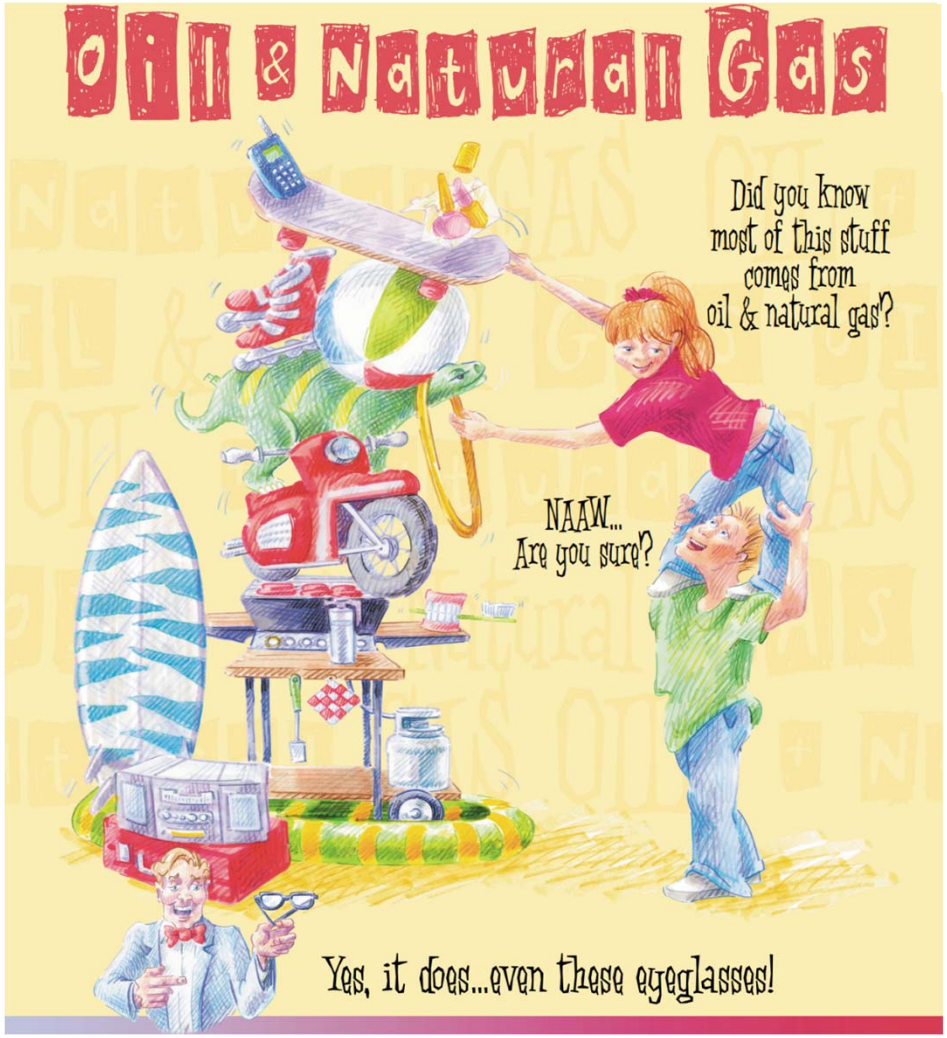
https://ec.europa.eu/research/bioeconomy/images/bioeconomy_graphic_full.jpg

Fossil hydrocarbons: much more than fuel

Global economies rely heavily on fossil hydrocarbons.



https://upload.wikimedia.org/wikipedia/commons/f/ff/Top_5_Importers_of_Petroleum.png



http://energy.gov/sites/prod/files/oil_gas_poster.pdf

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Fossil hydrocarbons: much more than fuel

http://energy.gov/sites/prod/files/oil_gas_poster.pdf

Can we survive without fossil hydrocarbons?

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Perhaps a better question is "can we afford to continue relying on fossil hydrocarbons?"

Fossil hydrocarbons have given us amazing benefits; however, we also know that they have been the root cause of many environmental and ecological disasters and their continued use is unsustainable. There are alternatives to fossil hydrocarbons and we MUST transition to alternatives to reverse the damage done to air, water and soil.

Imperative to change our patterns of production and consumption: from linear to circular.

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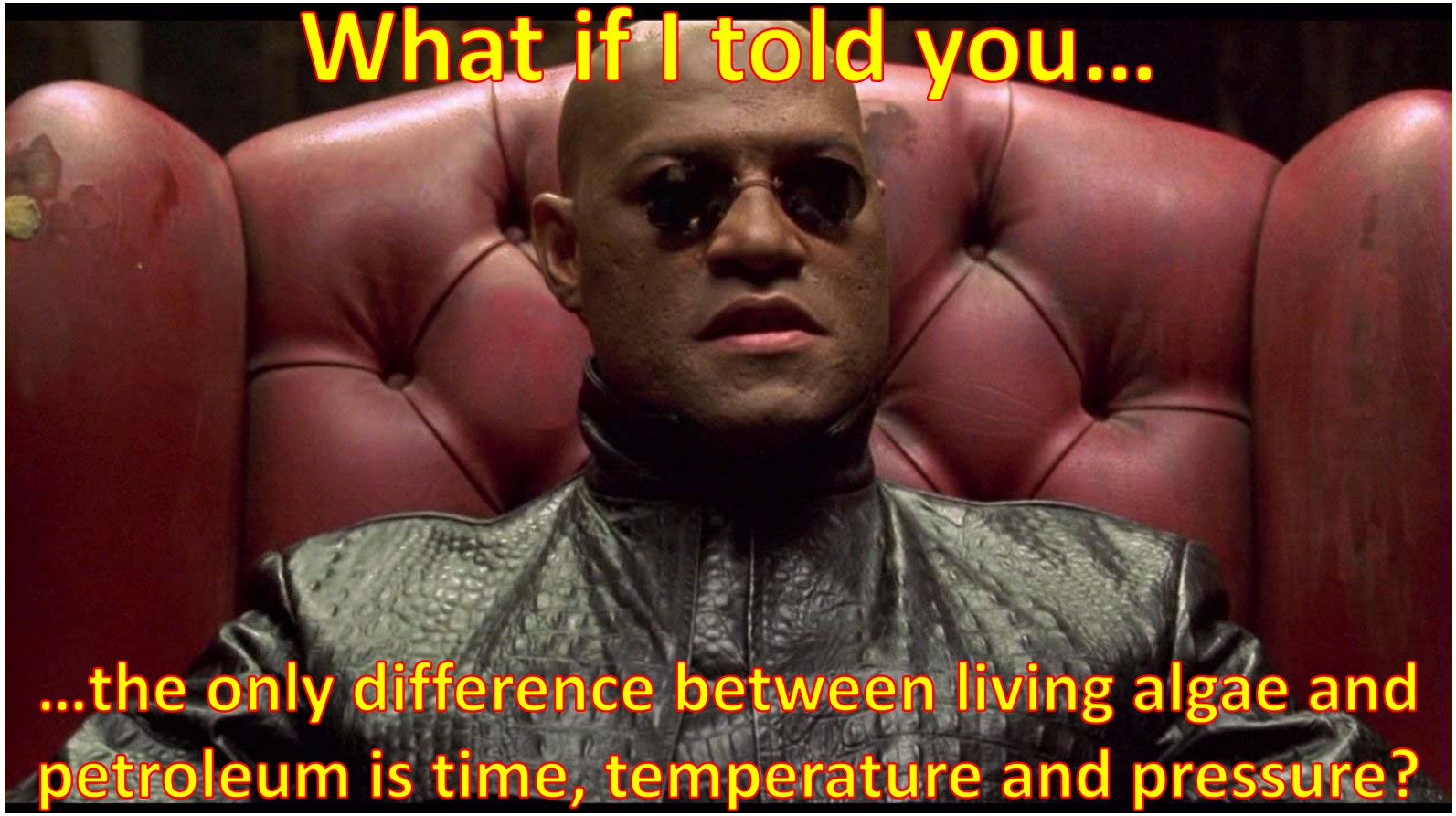

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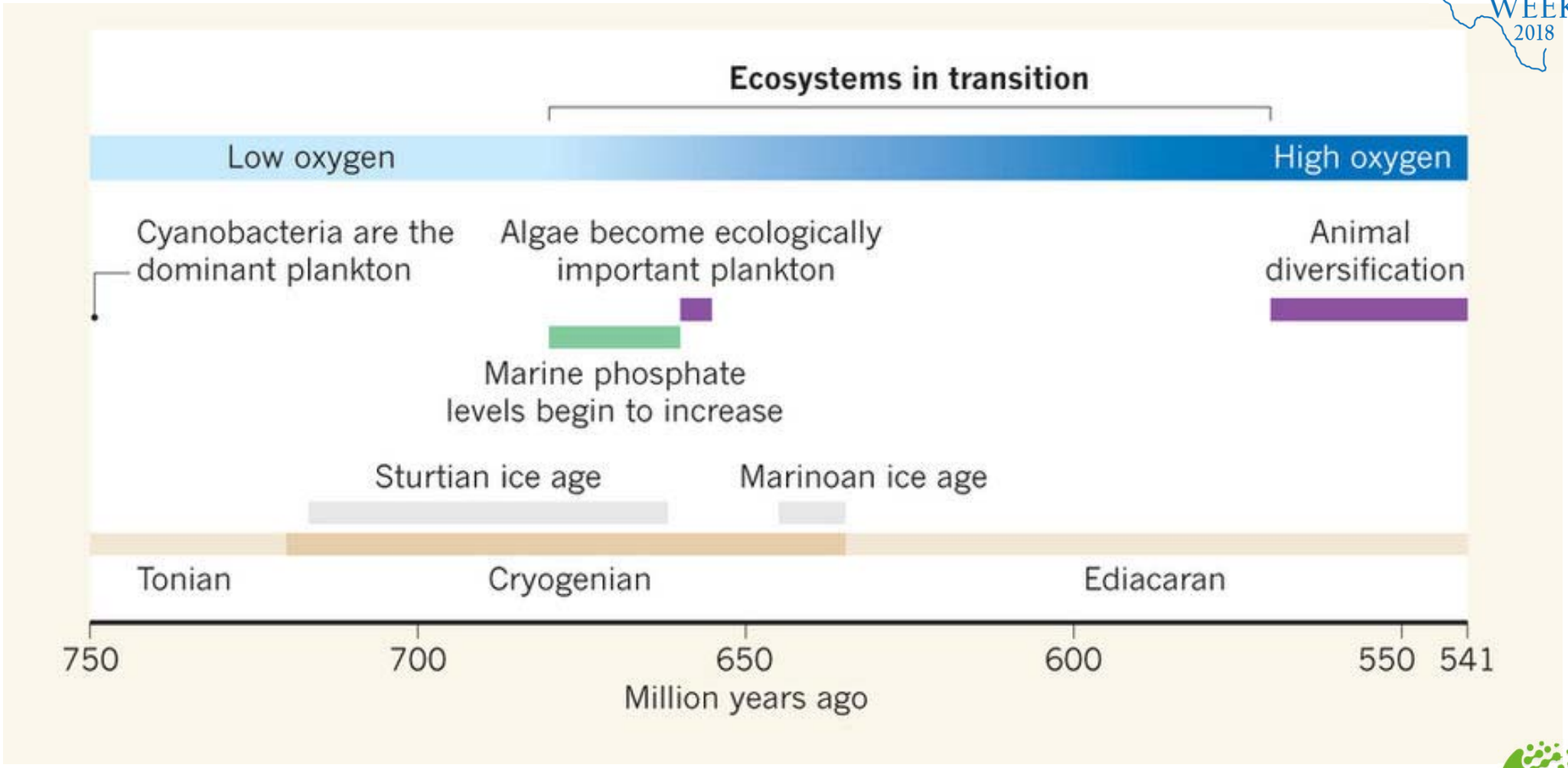
The Rise of Algae



Source: Brocks, Jochen J., *et al*. 2017

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If not for algae we would not be here!

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FACT: We would not be here if not for algae

PAST

- ✓ Oxygenated Earth's Atmosphere
- ✓ Diversified Mineral Resources
- ✓ First photosynthetic organisms
- ✓ Created Ozone Layer
- ✓ Enabled terrestrial life & photosynthesis
- ✓ Created hydrocarbon deposits

PRESENT

- ✓ Base of the aquatic food chain
- ✓ Largest source of O_2
- ✓ Primary Producers of just about everything organic
- ✓ Considered a nuisance by most

FUTURE

- ✓ Sequester CO_2
- ✓ Remediate wastewater
- ✓ Remediate soils
- ✓ Recycle nutrients
- ✓ Increase food production
- ✓ Nutraceuticals, Cosmeceuticals, Medical/Pharma
- ✓ Replace petroleum hydrocarbons

Prediction: Algae can help save our place on the planet

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Whatever Fossil Hydrocarbons can do…so can algae!

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Algae Products and Markets

Food Supplements	with microalgae, marine algae, dha and epa oils
Health Food Ingredient	In protein shakes, juice drinks, energy bars
Personal Care Products	creams, masks, shampoos, cleansers. cosmetics
Nutraceuticals, Medicinals	pigments, oils, antioxidants, medical diagnostics
Edible Seaweeds	nori, dulse, wakame, kelp, seasoning
Food Ingredient	proteins, pigments, thickeners, stabilizers, oils
Pet Food Ingredient	aquarium fish and specialty pet foods
Fish Feed Supplement	for survival, health, nutrition, coloration, omega 3
Animal Feed and Oils	for survival, health, nutrition, omega 3
Fertilizers	plant food, growth promoters, soil conditioners
Biopolymers	packaging, bioplastics, adhesives
Fine chemicals	industrial enzymes, esters, resins

Algae can do things that fossil hydrocarbons can't!

- Recover and recycle nutrients, e.g. phosphates, nitrates
- Clean wastewater: industrial and municipal (cheaper and better)
- Carbon Capture and Use (CCU) to reduce GHGs
- Bioremediate/rejuvenate soils (algae are primary producers) leading to increased food production
- Vital roles in all ecosystems: terrestrial, aquatic
- Single largest source of O2 on the planet
- Used for aquaponics and animal feed
- Produce natural substances beneficial to humans: pharmaceutical, nutraceutical, cosmeceutical, protein, etc.

Points to Ponder

- ✓ We live on a planet with finite resources and a finite capacity to absorb the impact of our activities.
- ✓ We must alter our patterns of production and consumption if we are to continue to derive social, environmental, and economic benefits: from linear to circular economy.
- ✓ We depend either directly or indirectly on the environment and natural resources for all economic activity and human well-being.
- ✓ Environmental goods and services are several orders of magnitude more valuable than total global GDP.

Points to Ponder

- ✓ Government's role is to create the legislative and policy framework to facilitate sustainable business practices. Some funds currently allocated to biofuels may be better assigned to other areas of bioeconomic technology and product development.

- ✓ The Private Sector must assume a greater role in achieving sustainable development goals and exploring business opportunities in the bioeconomy.

"***The cultivation of microalgae is known to be the most profitable business in the biotechnological industry. It is a waste-less, ecologically pure, energy and resource saving process.***" Priyadarshani, Indira and Biswajit Rath. (2012) "Commercial and industrial applications of micro algae – A review." *J. Algal Biomass Utln, 3 (4):89–100.*

"***If it is to be successful and thrive, the bioeconomy will be based on a steady flow of new products and services that address American needs. To ensure this flow, policies must be developed and taxpayer dollars must be used responsibly to foster an ecosystem that supports discovery, innovation, and commercialization.***" UNITED STATES. (2012). *National bioeconomy blueprint*. Washington, The White House. http://purl.fdlp.gov/GPO/gpo22194.

Take-home ideas

- ✓ Biofuels seek to replace fossil hydrocarbons largely as an energy source for vehicles or other power generation
- ✓ Climate change mitigation, electric motors and next-generation batteries are sounding the death knell for the internal combustion engine
- ✓ Renewable energy is rapidly gaining advantages over fossil hydrocarbons and is cheaper and cleaner on an unsubsidized levelized cost; Decentralized renewable power generation is rapidly gaining acceptance as a cheaper, cleaner, more resilient form of energy
- ✓ Biomass can be used for much more than energy
- ✓ Living bio-resources perform critical functions in regulating planetary systems and cycles
- ✓ Living bio-resources and non-living natural systems provide natural capital that far exceeds global GDP
- ✓ Living bio-resources can provide essential services, e.g. CO2 sequestration, wastewater treatment, pollution reduction
- ✓ We must transition from a fossil-based economy to a bioeconomy: a "post-petroleum world"

Closing Thoughts

"Sooner or later we will pay the same price to preserve what remains as we would have paid to keep what we had."

(David D. Ramjohn ca. 2013)

"We cannot 'save the planet'. It is highly anthropocentric of us to think that we can, or that the planet needs us to save it. The planet will go on long after we make it inhospitable to us. We must instead focus on **saving our place on the planet.**" (*Ibid.*)

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Recommended Reading

Brocks, Jochen J., *et al*. "The rise of algae in Cryogenian oceans and the emergence of animals." *Nature*, vol. 548, no. 7669, 2017, pp. 578–581., doi:10.1038/nature23457.

Groom, Martha; Gray, Elizabeth M. & Townsend, Patricia. (2008). "Biofuels and Biodiversity: Principles for Creating Better Policies for Biofuel Production." Conservation biology: *Journal of the Society for Conservation Biology*. 22. 602-9. 10.1111/j.1523-1739.2007.00879.x.

Biofuelwatch UK. (2017) "Microalgae Biofuels: Myths and Risks." *http://www.biofuelwatch.org.uk/wp-content/uploads/Microalgae-Biofuels-Myths-and-Risks-FINAL.pdf*

Llewellyn, J. (2007). *The business of climate change: challenges and opportunities*. London: Lehman Brothers. http://www.climateneeds.umd.edu/reports/Lehman%20Bros,-The%20Business%20of%20Climate%20Change.pdf

Facets, Piraeus Bank, WWF Greece, "*Climate Change and Business Opportunities*". LIFE+ Project "climabiz". Athens: 2011 http://climate-adapt.eea.europa.eu/metadata/case-studies/financial-institutions-preparing-the-market-for-adapting-to-climate-change-2013-climabiz/11261472.pdf

KPMG International. What are the global megatrends? (n.d.). Retrieved November 03, 2017, from https://home.kpmg.com/xx/en/home/insights/2013/10/what-are-the-global-megatrends.html

Recommended Reading

Brook, Clare. (2011, November 01). Spectacular population growth creates investment opportunities. Guardian Professional Network. Retrieved November 03, 2017, from https://www.theguardian.com/sustainable-business/blog/population-growth-resources-investment-opportunities

Population growth megatrend: Environmental Resources Management (ERM) Sustainability Report 2017. (n.d.). Retrieved November 03, 2017, from https://www.erm.com/en/sustainabilityreport2017/megatrends/population-growth/

Simplice, Asongu. (2013). How Would Population Growth Affect Investment in the Future? Asymmetric Panel Causality Evidence for Africa. African Development Review. 25. . 10.1111/j.1467-8268.2013.12010.x.

Petroff, A. (2017, September 11). These countries want to ban gas and diesel cars. Retrieved November 03, 2017, from http://money.cnn.com/2017/09/11/autos/countries-banning-diesel-gas-cars/index.html

© OECD/IEA, 2017 International Energy Agency. Global EV Outlook 2017: Two million and counting. IEA Publishing. Licence: www.iea.org/t&c https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

Pedrosa, D., Monteiro, V., Goncalves, H., Martins, J. S., & Afonso, J. L. (2014). *A Case Study on the Conversion of an Internal Combustion Engine Vehicle into an Electric Vehicle*. 2014 IEEE Vehicle Power and Propulsion Conference (VPPC). doi:10.1109/vppc.2014.7006994 http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7006994

Recommended Reading

Mahieux , C., & Oudalov, A. (2015, December 01). Microgrids enter the mainstream. Retrieved November 03, 2017, from http://www.renewableenergyfocus.com/view/43345/microgrids-enter-the-mainstream/

Shahan, Z. (2017, August 13). Low Costs of Solar Power & Wind Power Crush Coal, Crush Nuclear, & Beat Natural Gas. Retrieved November 03, 2017, from https://cleantechnica.com/2016/12/25/cost-of-solar-power-vs-cost-of-wind-power-coal-nuclear-natural-gas/

Mims, C. (2017, October 15). Your Next Home Could Run on Batteries. Retrieved November 03, 2017, from https://www.wsj.com/articles/your-next-home-could-run-on-batteries-1508065205

Bradley, P. (2016, May 4). Vermont Utility Starts Installing Tesla Home Batteries. Retrieved November 03, 2017, from http://wamc.org/post/vermont-utility-starts-installing-tesla-home-batteries

Ruz, C. (2011, October 31). The six natural resources most drained by our 7 billion people. Retrieved November 03, 2017, from https://www.theguardian.com/environment/blog/2011/oct/31/six-natural-resources-population

World Economic Forum (2012, December 14). What If the World's Soil Runs Out? Retrieved November 03, 2017, from http://world.time.com/2012/12/14/what-if-the-worlds-soil-runs-out/

Recommended Reading

Eswaran, H., R. Lal and P.F. Reich. 2001. Land degradation: an overview. In: Bridges, E.M., I.D. Hannam, L.R. Oldeman, F.W.T. Pening de Vries, S.J. Scherr, and S. Sompatpanit (eds.). Responses to Land Degradation. Proc. 2nd. International Conference on Land Degradation and Desertification, Khon Kaen, Thailand. Oxford Press, New Delhi, India. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2_054028

Tol, Richard S. 2002. "Estimates of the Damage Costs of Climate Change Part I and II" Environmental and Resource Economics 21: 135–160, 2002. Kluwer Academic Publishers. http://aida.econ.yale.edu/~nordhaus/homepage/documents/tol_impacts_I_ERE_21.pdf

Handmer, J.W., S. Dovers, and T.E . Downing. 1999. "Societal Vulnerability to climate change and variability." Mitigation and Adaptation Strategies for Global Change 4: pp. 267–281.

Visser, W. (2014, July 16). How to use technology to make our planet more sustainable, not less. Retrieved November 03, 2017, from https://www.theguardian.com/sustainable-business/technological-innovation-sustainability-energy-green-investment

Cann, Oliver. Head of Media Content, World Economic Forum Geneva. (2016, June 23). These are the top 10 emerging technologies of 2016. Retrieved November 03, 2017, from https://www.weforum.org/agenda/2016/06/top-10-emerging-technologies-2016