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Global Climate Change

BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

Project Number: KA220-BW-23-30-126516

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Contents

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General topic of the learning path	
Specific name of the learning unit	Global Climate Change
Age of the target users	14-18 years
Requirements for the learner	Basic knowledge of Science Access to AR-compatible devices (smartphones, tablets, or AR glasses)
Description of the learning unit	This unit introduces teachers and students to Climate change and global challenges that Europe need to face in the next years while incorporating Augmented Reality (AR) for a more immersive and interactive experience.
Subject: Parties involved	Science, chemistry
Keywords	Climate change, greenhouse gases, CO_2 emissions, renewable energy, mitigation strategies, sustainability, biomimicry, SDGs, adaptation, global warming, augmented reality, environmental impact, climate equity.
Key qualifications, skills and knowledge that can be acquired	• Scientific Literacy: Understanding the causes and effects of climate change through the carbon cycle, greenhouse effect, and human impact. • Critical Thinking: Evaluating various climate solutions and their feasibility, effectiveness, and ethical implications. • Digital Competence: Using AR tools to visualize data, simulate environments, and build interactive models.

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	• Collaboration and Communication: Working in teams to design solutions and present arguments or strategies using multimedia and AR-enhanced visuals. • Systems Thinking: Connecting climate topics with the UN Sustainable Development Goals, recognizing their interdependence. • Innovation: Applying bio-inspired and technological strategies (e.g., biomimicry) to solve real-world climate challenges creatively.
Resources and didactic aids used	• Digital Tools:Augmented Reality apps • Climate simulators and dashboards (e.g., NASA Climate, Global Carbon Atlas) • Multimedia Content: Educational videos • Infographics on SDGs and carbon emissions trends • Printable Materials: Wedge worksheets for climate mitigation strategies • Reflection journals or design briefs • Physical Aids: Gameboards for carbon wedge selection • 3D-printed models (optional, if available)
Assessment criteria and evaluation	• The student clearly explains the causes, effects and consequences of climate change, demonstrating accurate scientific understanding. • Application of AR tools The student effectively uses augmented reality to explore, illustrate or manipulate climate systems, biomimetic models or sustainable solutions. • Link to SDGs The student links climate issues to the United Nations Sustainable Development Goals (in particular SDG 13), demonstrating systemic thinking. • Creativity and innovation The student designs an original or adapted climate solution (e.g., a bio-inspired technology), clearly explaining the scientific and design rationale. • Collaboration and communication The student actively participates in group work, presents ideas clearly, and uses augmented reality to enhance explanation and engagement in the presentation. • Critical thinking The student critically evaluates the feasibility and impact of

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	different strategies, identifying trade-offs and stakeholder perspectives. • Reflective thinking The student reflects on their own learning process, the challenges of combating climate change and the implications of the proposed solution.

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1. Evidence of Climate Change

Human effect on the global climate is evident and increasing, with impacts observed amongst all continents and oceans.

Figure 1 - Human Activities on Earth

Several of the observed shifts since the 1950s are unparalleled over decades to millennia.
The IPCC (Intergovernmental Panel on Climate Change) is 95% confident that mankind is now the primary cause of the recent global climate change. In fact, the more industrial activities disrupt the climate, the greater the chances of extreme, permanent and inevitable impacts for humans and the environment, and lengthy shifts in all climate system[1].
Scientists have been able to see the big picture thanks to Earth-orbiting satellites and other technical advancements, which have enabled them to gather a wide range of data about our world and its environment on a global scale. The signs of a changing environment are exposed in this body of evidence, which has been accumulated over several years.

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[1] IPCC Fifth Assessment Report, Summary for Policymakers

B.D. Santer et.al., "A search for human influences on the thermal structure of the atmosphere," Nature vol 382, 4 July 1996, 39-46

Gabriele C. Hegerl, "Detecting Greenhouse-Gas-Induced Climate Change with an Optimal Fingerprint Method," Journal of Climate, v. 9, October 1996, 2281-2306

V. Ramaswamy et.al., "Anthropogenic and Natural Influences in the Evolution of Lower Stratospheric Cooling," Science 311 (24 February 2006), 1138-1141

B.D. Santer et.al., "Contributions of Anthropogenic and Natural Forcing to Recent Tropopause Height Changes," Science vol. 301 (25 July 2003), 479-483.

Figure 2 Ice melting in the North Pole

Since the late 1800s, the planet's average surface temperature has risen by around 2.12 degrees Fahrenheit (1.18 degrees Celsius), due primarily to increased carbon dioxide pollution into the atmosphere and other human activities[2]. The last 40 years have experienced the most warming, with the last seven years being the warmest. 2016 and 2020 are tied for the warmest year ever recorded[3]. Carbon dioxide and other gases' ability to absorb heat was shown in the mid-nineteenth century[4]. Many NASA instruments are based on their ability to control the flow of infrared energy through the atmosphere. There is no doubt that the levels of greenhouse gases would cause the Earth to burn.

Greenland, Antarctica, and tropical mountain glaciers have also produced ice cores that demonstrate how the Earth's atmosphere reacts to increases in greenhouse gas levels. Tree rings, ocean sediments, coral reefs, and layers of sedimentary rocks all provide ancient evidence.

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[2] https://www.ncdc.noaa.gov/monitoring-references/faq/indicators.php

https://crudata.uea.ac.uk/cru/data/temperature/

http://data.giss.nasa.gov/gistemp

[3] https://www.giss.nasa.gov/research/news/20170118/

[4] In 1824, Joseph Fourier determined that at our distance from the Sun, an Earth-sized planet must be very cold. He speculated that something in the atmosphere was acting like an insulator. Eunice Foote discovered the blanket in 1856, demonstrating that the atmosphere's carbon dioxide and water vapor trap escaping infrared (heat) radiation. John Tyndall, a physicist, recognised Earth's natural greenhouse effect in the 1860s and proposed that small differences in atmospheric chemistry may cause climatic variations. Svante Arrhenius, a Swedish scientist, predicted that increases in ambient carbon dioxide levels could significantly alter surface temperature through the greenhouse effect in a landmark paper published in 1896. Guy Callendar attributed rising carbon dioxide levels in the atmosphere to global warming in 1938. Milutin Milankovic identified a correlation between ice ages and Earth's orbital characteristics in 1941. In 1956, Gilbert Plass proposed the Carbon Dioxide Theory of Climate Change.

This ancient evidence, known as paleoclimate, shows that recent warming is about ten times faster than in the past. During the last Ice Age, carbon dioxide from human activities increased more than 250 times more than it did from natural causes[5].
Rapid climate change is supported by persuasive evidence:

- Temperature Rise
- Warmer Oceans
- Retreat of glaciers
- Ice Sheets That Are Shrinking
- Rise of Sea Levels
- Reduced Snow Coverage
- Extreme weathers
- Arctic Sea Ice Melting
- Acidification of the Oceans

2. What are the causes of Climate Change?

The "greenhouse effect"[6] — warming that happens as the atmosphere traps heat radiating from Earth into space — has been expanding due to human expansion since the mid-twentieth century, according to science.
The presence of such gases in the atmosphere inhibits heat from escaping. Long-lived gases that persist in the atmosphere semi-permanently and do not react physically or chemically to temperature changes are referred to as "forcing" climate change. "Feedbacks" are gases, such as water vapor, that respond physically or chemically to temperature changes.
The following gases contribute to the greenhouse effect:

[5] Vostok ice core data; NOAA Mauna Loa CO_2 record
Gaffney, O.; Steffen, W. (2017). "The Anthropocene equation," The Anthropocene Review (Volume 4, Issue 1, April 2017), 53-61.

[6] IPCC Fifth Assessment Report, 2014
United States Global Change Research Program, "Global Climate Change Impacts in the United States," Cambridge University Press, 2009
Naomi Oreskes, *"The Scientific Consensus on Climate Change,"* Science 3 December 2004: Vol. 306 no. 5702 p. 1686 DOI: 10.1126/science.1103618

- Vaporized water. It is the most abundant greenhouse gas, but it also serves as a climate feedback. As the Earth's atmosphere warms, water vapor levels rise, but so do the chances of clouds and snow, making these two feedback systems crucial to the greenhouse effect.

- Carbon dioxide (CO2). It's a small but critical part of the atmosphere, is emitted by natural phenomena such as respiration and volcanic eruptions, as well as by human activity such as deforestation, land use modifications, and fossil fuel combustion. Since the advent of the Industrial Revolution, humans have raised CO2 levels in the environment by 47%. The most critical long-term "forcing" of climate change is this.

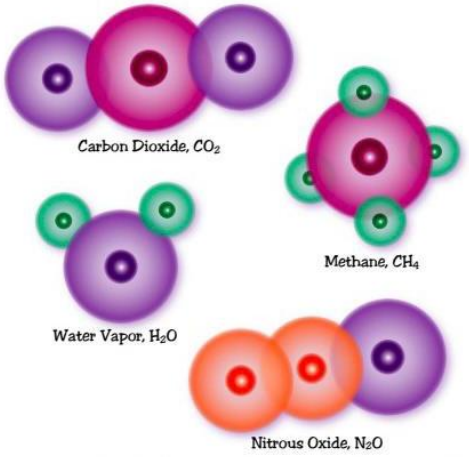

Figure 3 Greenhouse gases molecules

- Methane. A hydrocarbon gas generated by both natural and human factors, such as waste decomposition in landfills, agriculture, and particularly rice cultivation, as well as ruminant digestion and manure management in domestic livestock. Methane is a much more potent greenhouse gas than carbon dioxide molecule for molecule, but it is still far less abundant in the atmosphere.
- Nitrous oxide is a chemical. Soil cultivation activities, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning, all generate a considerable amount of this powerful greenhouse gas.

- Chlorofluorocarbons (CFCs) are a form of fluorocarbon CFCs). They are synthetic chemicals entirely of industrial origin used in a variety of uses, but, thanks to an international agreement they are primarily

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imited in manufacture and release into the environment due to their potential to lead to ozone layer degradation. In addition, they are greenhouse gases.

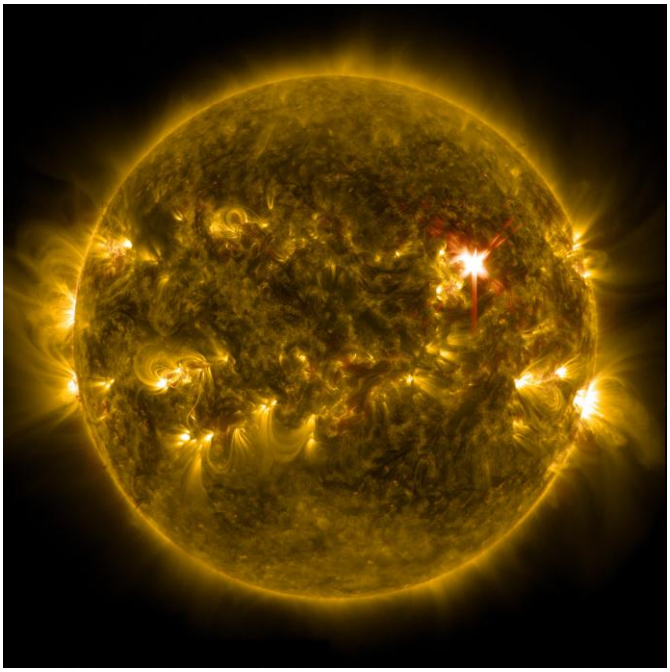

Figure 4 – Earth's heat

Human activities on Earth are altering the existing greenhouse. The combustion of fossil fuels such as coal and oil has increased the abundance of carbon dioxide in the atmosphere over the past century. This is because the combustion of coal or oil produces CO2 by combining carbon with oxygen. The clearance of land for agriculture, manufacturing, and other human activities has raised greenhouse gas emissions to a smaller degree.

Changes in the natural atmospheric greenhouse's outcomes are difficult to foresee, but the following results seem to be likely:

- Normally, the Earth's temperature would rise. Warmer temperatures can be welcomed in some areas, but not in others.
- Warmer weather could be likely result in more evaporation and more precipitation overall, but some particular regions could also see varying results. Indeed, some of them could becoming wetter and others dryer.
- A greater greenhouse effect would warm the ocean and cause glaciers and ice sheets to partly melt, increasing sea levels. When the ocean warms, the water expands, adding to the increase of sea level.
- Higher atmospheric carbon dioxide (CO2) levels may have both positive and negative impacts on crop yields outside of a greenhouse. Plant development can be aided by increased CO2 levels, according to some laboratory studies.

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Droughts, flooding, and extreme temperatures are examples of climate extremes that can cause crop losses and endanger agricultural producers' livelihoods as well as community food security around the world. Weeds, pests, and fungi could prosper in warmer temperatures, wetter winters and higher CO2 levels. Depending on the crop and ecosystem, climate will change likely exacerbate weeds and pests.
Finally, since increased CO2 stimulates plant growth, research has already shown that decreases the nutritional value of most crops by lowering protein and essential nutrient concentrations in most species of plants[7].

Human Activity and Its Importance

In the past 150 years, the industrial processes that underpin our modern culture have increased atmospheric carbon dioxide levels from 280 parts per million to 414 parts per million.
The panel also argued that human-produced greenhouse gases like carbon dioxide, methane, and nitrous oxide are likely to be blamed for much of the observed rise in Earth's temperature over the past 50 years.

Irradiance of the Sun

Because the Sun is the essential source of energy that drives our climate system, it's appropriate to presume that changes in the Sun's energy output will cause the climate to change.
Solar variability has been shown to play a role in previous climate changes in experiments. For example, between around 1650 and 1850, a decrease in solar activity combined with an increase in volcanic activity is believed to have aided in the onset of the Little Ice Age, when Greenland cooled from 1410 to the 1720s and glaciers advanced in the Alps.
However, some lines of evidence show that current global warming is unrelated to changes in solar energy:

The average amount of energy emitted by the Sun has remained constant or risen slightly since 1750.
Warmer temperatures would be expected in all layers of the atmosphere if the warming was caused by a more active Sun. Instead, they've noticed a cooling in the upper atmosphere, as well as a warming at the surface and in the lower atmosphere because greenhouse gases trap heat in the lower atmosphere.
Climate models that account for changes in solar irradiance are unable to replicate the observed temperature trend over the past century or more without accounting for an increase in greenhouse gas emissions.

[7]https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-agriculture-and-food-supply_.html

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3. Climate Change Effects

Figure 5 - More frequent wildfires, longer drought periods in some areas, and an increase in the number, severity, and intensity of tropical storms are all possible future impacts of global climate change.

The environment has already been affected by global climate change. Glaciers have shrunk, ice on rivers and lakes has broken up earlier, plant and animal ranges have changed, and trees have begun to bloom earlier.

Sea ice loss accelerated sea level rise, and longer, more severe heat waves are all effects that scientists expected will arise as a result of global climate change in the past.

Scientists are confident that global temperatures will continue to increase for decades to come, owing in large part to greenhouse gas emissions caused by human activities. Over 1,300 scientists from the United States and other nations make up the Intergovernmental Panel on Climate Change (IPCC), which predicts a temperature increase of 2.5 to 10 degrees Fahrenheit over the next century.

The extent of climate change impacts on individual regions will vary over time and with the ability of various cultural and environmental systems to alleviate or adapt to change, according to the IPCC.

Increases in global mean temperature of less than 1.8 to 5.4 degrees Fahrenheit (1 to 3 degrees Celsius) above 1990 levels, according to the IPCC, would have useful effects in some areas and detrimental effects in others. As world temperatures rise, net annual expenses will rise as well.[8]

[8] IPCC 2007, Summary for Policymakers, in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge, UK, p. 17.
IPCC, 2013: Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Future Consequences

According to the Third and Fourth National Climate Assessment Reports, some of the long-term implications of global climate change in the United States include:

- Change Will Persist Throughout This Century and Into the Next
- Temperatures are expected to continue to rise
- The Frost-Free Season (the Growing Season) will be longer
- Precipitation Patterns Have Changed
- Droughts and heat waves are becoming more common
- Hurricanes will become more powerful and severe
- By 2100, the sea level would have risen 1-8 feet (30-240 cm)
- The Arctic is likely to become ice-free in the near future

Figure 6 - A polluted globe

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4. Climate Change Solutions

What is the extent of climate change? That will be determined by how long we continue to emit greenhouse gases and how our climate system reacts to them. Despite growing awareness of climate change, our greenhouse gas emissions continue to soar at an alarming rate. For the first time in human history, the daily level of carbon dioxide in the atmosphere exceeded 400 parts per million in 2013. The last time levels were that high was during the Pliocene Epoch, about three to five million years ago. Because we are now committed to some degree of climate change, we must take a two-pronged approach to combating it:

- Adapting to climate change that is already underway ("adaptation");
- Mitigating climate change by reducing emissions and stabilizing levels of heat-trapping greenhouse gases in the atmosphere ("mitigation").

Figure 7 – Activists'' poster

Adaptation and Mitigation

Adapting to life in a changing environment entails making adjustments to the current and expected future climate. The aim is to decrease our vulnerability to climate change's negative consequences (like sea-level encroachment, more intense extreme weather events or food insecurity). It also includes making the most

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of any potentially helpful climate change opportunities (for example, longer growing seasons or increased yields in some regions).

People and cultures have responded to and coped with changes in climate and extremes to varying degrees of success throughout history.

Climate change (and particularly drought) has played a role in the rise and fall of civilizations. For the past 12,000 years, Earth's climate has been comparatively stable, which has been beneficial for the survival of our modern civilization and life as we know it. The stable climate to which we have grown used has shaped modern life. We will have to learn to adapt as our climate changes. The more rapidly the climate changes, the more difficult it may become. While climate change is a global problem, it has a local impact. As a result, cities and countries are at the forefront of adaptation.

Cities and local governments around the country have been focusing on addressing their own climate issues in the absence of national or international climate policy direction. They're working to develop flood defences, prepare for heat waves and warmer temperatures, and install water-permeable pavements to better handle flooding and stormwater.

Governments at all levels are improving their adaptation skills, according to the United Nations Intergovernmental Panel on Climate Change's 2014 report on Climate Change Impacts, Adaptation, and Vulnerability (page 8).

Climate change is beginning to be incorporated into a wide range of development plans, along with how to manage the increasingly extreme disasters we're seeing and the risks they pose, how to safeguard coastlines and deal with sea-level incursion, how to better handle land as well as forests, how to cope with and plan for water scarcity, how to grow resilient crop varieties, and how to preserve energy and public infrastructure.

5. Agenda 2030

Even though there is only one planet Earth, the planet is consuming, and it will consume resources as if there were three by 2050. In the next 40 years, global consumption of biomass, fossil fuels, metals, and minerals is expected to double, while annual waste production is expected to rise by 70% by 2050.

Since resource production and processing account for half of overall greenhouse gas emissions and more than 90% of biodiversity depletion and water stress, the European Green Deal developed a detailed response for a climate-neutral, resource-efficient, and sustainable economy.

Scaling up the circular economy from early adopters to mainstream economic actors would lead greatly to achieving climate neutrality by 2050 and decoupling economic development from resource consumption, all while maintaining the EU's long-term competitiveness and leaving no one behind. To achieve this goal, the EU must accelerate the transition to a regenerative growth paradigm that gives back more to the earth than it takes, make progress in maintaining resource use within global limits, and aim to reduce its consumption footprint and double its circular material usage levels in the next decade.

Working together to create a structure for recycled goods would open up new possibilities for companies in the EU and beyond.

The new EU industrial policy must contain this phased yet permanent transition to a sustainable economic environment. According to a recent report, incorporating circular economy concepts across the EU

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economy has the potential to raise GDP by 0.5 percent by 2030, resulting in the production of 700.000 new jobs.

Figure 8 - Agenda 2030

Closed loop models can maximize profitability while shielding businesses from resource price fluctuations, which is a straightforward business argument for individual companies. Manufacturing firms in the EU spend around 40% on goods on average, so closed loop models can improve profitability while shielding them from resource price fluctuations.

The circular economy will reinforce the EU's manufacturing base and promote business growth and entrepreneurship among SMEs by exploiting the single market and the power of digital technology. Innovative models focusing on a stronger interaction with consumers, mass customization, the sharing and collaborative economy, and driven by emerging technology like the internet of things, big data, blockchain, and artificial intelligence will not only intensify circularity, but also the dematerialisation of our economy, reducing Europe's reliance on primary materials.

The circular economy would provide people with high-quality, practical, and sustainable goods that are reliable, inexpensive, and designed for reuse, repair, and high-quality recycling. A new set of sustainable services, product-as-a-service models, and emerging solutions would result in increased quality of living, new work prospects, and improved knowledge and skills.

In collaboration with economic leaders, consumers, individuals, and civil society organizations, this Circular Economy Action Plan offers a future-oriented agenda for creating a cleaner and more sustainable Europe. Its aim is to accelerate the transformational change demanded by the European Green Deal, while still building on circular economy initiatives that have been in place since 2015. This strategy would ensure that the regulatory system is simplified and made ready for a prosperous future, that potential possibilities emerging from the transformation are maximized, and that individuals and companies are burdened as little as possible. The strategy lays out a series of interconnected policies aimed at establishing a clear and

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consistent product policy structure that will make renewable goods, services, and business models the standard, as well as change consumption habits so that no waste is created in the first place.
This product policy structure would be gradually implemented, with main product value chains receiving priority attention. Additional steps will be introduced to minimize pollution and ensure that the EU's internal demand for high-quality secondary raw materials is well-functioning. The EU's willingness to take responsibility for its pollution would be bolstered as well. By working alone, Europe would not be able to make transformative reform.
On a global scale, the EU will continue to lead the way toward a circular economy, using its authority, experience, and financial tools to help countries meet the 2030 Sustainable Development Goals.
This policy seeks to ensure that the circular economy supports individuals, countries, and communities, contributes completely to climate neutrality, and fully exploits the potential of science, creativity, and digitalization. It envisions the continued implementation of a sound monitoring system that can help to measure well-being in ways other than GDP.

6. SDGs ONU

The 2030 Agenda for Sustainable Development was unveiled in 2015 with the aim of eradicating poverty and putting the world on a path toward stability, growth, and opportunity for all people on a safe planet. The 17 Sustainable Development Goals (SDGs) call for a complete overhaul of the financial, economic, and political structures that control our economies today in order to ensure that everyone's human rights are protected. They necessitate tremendous political will and bold action on the part of all stakeholders. However, as Member States acknowledged at the SDG Summit in September, existing global initiatives have fallen short of delivering the transition required, jeopardizing the Agenda's commitment to current and future generations.
Before the COVID-19 pandemic, growth was uneven, and we were not on target to achieve the Goals by 2030, according to the Sustainable Development Goals Study 2020. There were some visible gains: the number of children and youth out of school had decreased; the prevalence of certain communicable diseases had decreased; access to clean drinking water had improved; and women's participation in leadership positions had increased. At the same time, the number of people facing food malnutrition was increasing, the environmental ecosystem was declining at an unprecedented pace, and drastic levels of deprivation continued in all regions.
Change was also not occurring at the appropriate rate or size. Now, as a result of COVID-19, an ongoing health, economic, and social crisis threatens lives and livelihoods, rendering the accomplishment of the Goals much more difficult. The death toll had reached 400,000 people by the beginning of June, and it was still increasing, with almost no nation untouched. Many countries' health-care services are on the verge of disintegrating. Half of the world's population has had their livelihoods seriously impacted. More than 1.6 billion students are out of school, and tens of millions of people are being forced back into chronic poverty and malnutrition, reversing recent gains.

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The novel coronavirus affects everybody, and every culture and it has highlighted and amplified existing inequality and injustices. In emerging economies, vulnerable populations have had the highest fatality rates. The most disadvantaged populations in developed countries, such as those working in the informal economies, the elderly, teenagers, people with disabilities, indigenous peoples, migrants, and refugees, are at risk of being struck even harder.

Young people are overwhelmingly impacted across the world, especially in the workplace.

Women and girls are confronted with new challenges and risks, ranging from a looming pandemic of abuse to the added pressures of unpaid care work. Rather than challenging the case for the SDGs, COVID-19's root causes and unequal effects highlight the importance of the 2030 Agenda, the Paris Climate Agreement, and the Addis Ababa Action Agenda, as well as the speed of which they must be implemented. As a result, it has been repeatedly called for a concerted and systematic international response and recovery effort, driven by the Sustainable Development Goals and focused on sound evidence and research.

Figure 9 - SDGs

In countries that are most at risk, health services must be rapidly improved, with expanded potential for monitoring, tracing, and care. When medications and vaccines become affordable, universal coverage is critical. To ensure that developed countries have the tools they need to defend their households and enterprises, a large-scale multilateral response is needed. Recovery packages would promote equitable access to high-quality public services while also facilitating the transition to a low-carbon, climate-resilient economy. Leadership and guidance are also needed to ensure that statistical organisations have the tools and services they need to make timely and intelligent decisions.

The United Nations system has organized at all levels to direct and encourage these actions, incorporating recent UN development system changes. We all call for increased determination, mobilization, leadership,

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and concerted action at the outset of this Decade of Action to deliver the SDGs, not only to defeat COVID-19, but to rebound best, collectively – winning the fight against climate change, decisively addressing poverty and injustice, genuinely empowering all women and girls, and building more sustainable and egalitarian communities everywhere.

Below, the 17 SDGs:

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlement inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, sea and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalise the global partnership for sustainable development

In the EU and beyond, the transition to a circular economy should be structural, intense, and transformative. All stakeholders at all levels - EU, global, regional, and local, as well as international - will need to align and cooperate.

As a result, the Commission urges EU agencies and organizations to support and effectively participate in the adoption of this Action Plan, as well as Member States to enact or revise their national circular economy policies, plans, and initiatives in light of its ambition.

In addition, the Commission will propose that circular economy must be included among the subjects for debate on Europe's future as well as a regular subject of citizens' dialogues.

7. Augmented Reality (AR) Integration

Global climate change is one of the most serious challenges of our time, with interconnected causes, effects and solutions that require collective action on a global scale. The main causes of climate change are linked to the increase in greenhouse gases (such as CO_2, methane and nitrous oxide), produced mainly by the combustion of fossil fuels, deforestation, intensive agriculture and industrial activities. Thanks to

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augmented reality, students can visualise the carbon cycle in 3D or observe interactive models of the greenhouse effect to understand how these gases trap heat in the atmosphere. The effects of climate change include sea level rise, extreme weather events, biodiversity loss, drought and environmental migration. Through AR, it is possible to superimpose future scenarios onto one's local environment (e.g., what the coastline of one's city will look like in 2050), making the impacts more tangible and personal. Solutions include the transition to renewable energy, energy efficiency, reforestation, sustainable mobility and changes in consumption. With AR, students can virtually build sustainable cities, explore solar or wind power plant models, or simulate the emissions avoided by certain choices. Climate change is directly linked to Sustainable Development Goal 13 (Climate Action), but it also affects many other SDGs (such as zero hunger, good health, clean water, and sustainable cities). With AR, interactive maps can be created that link the various SDGs, showing in real time how each climate action has cross-cutting effects on global well-being. Integrating augmented reality into these topics makes learning experiential: students don't just read data, they see and manipulate it in real space. This stimulates critical understanding, collaboration and greater awareness of their impact on the planet.

8. Conclusion: The Future of AR in Vision Science

Integrating Augmented Reality (AR) into bio-inspired vision research transforms how students learn, experiment, and innovate. Through immersive 3D simulations, interactive visual mapping, and AI-powered analytics, AR bridges the gap between biological vision science and engineered optical systems.

By experiencing hands-on AR-enhanced learning, the next generation of scientists and engineers will be better equipped to develop advanced bionic vision technologies, AI-driven robotic sensors, and augmented optical interfaces, shaping the future of bio-inspired innovation.

Phase	Description
Explore	Visualise the greenhouse effect in 3D and track gas levels over time. Experience local scenarios projected onto your own city (e.g. sea level rise in 2050). With AR, you can overlay historical data and future projections onto the real world, stimulating understanding and critical thinking.
Execute	During lessons, groups of students design AR prototypes to combat climate change: • An urban installation of solar panels inspired by self-cleaning lotus leaves. • A “forest city” that combines greenery and natural ventilation (biomimicry). In real time, they compare avoided emissions, costs and impacts through AR visualisations and receive feedback from classmates and teachers.

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Enhance	• **High-fidelity simulations**: immersive exploration (e.g., ocean currents, virtual rainforests). • **Annotation and manipulation**: students modify energy parameters, test impacts and add labels to AR structures. • **Gamification**: they earn points by solving interactive quizzes matching causes, effects and solutions, advance through design levels and participate in collaborative challenges. • **AR assessments**: interactive quizzes, presentations with enhanced 3D models and dashboards that monitor engagement and understanding in real time.

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Princeton University Carbon Mitigation Initiative: http://cmi.princeton.edu/

Changing Climates at Colorado State University: http://changingclimates.colostate.edu/

IPCC Working Group III Report "Mitigation of Climate Change", Chapters 4, 5 & 6
http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm

IPCC Special Report on Carbon dioxide Capture and Storage, SPM
http://www.ipcc.ch/pdf/specialreports/srccs/srccs_summaryforpolicymakers.pdf

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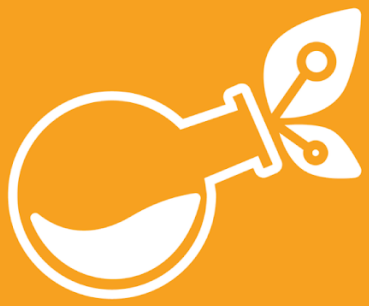

BIOS4YOU AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

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