

COP29:

CLIMATE CHANGE



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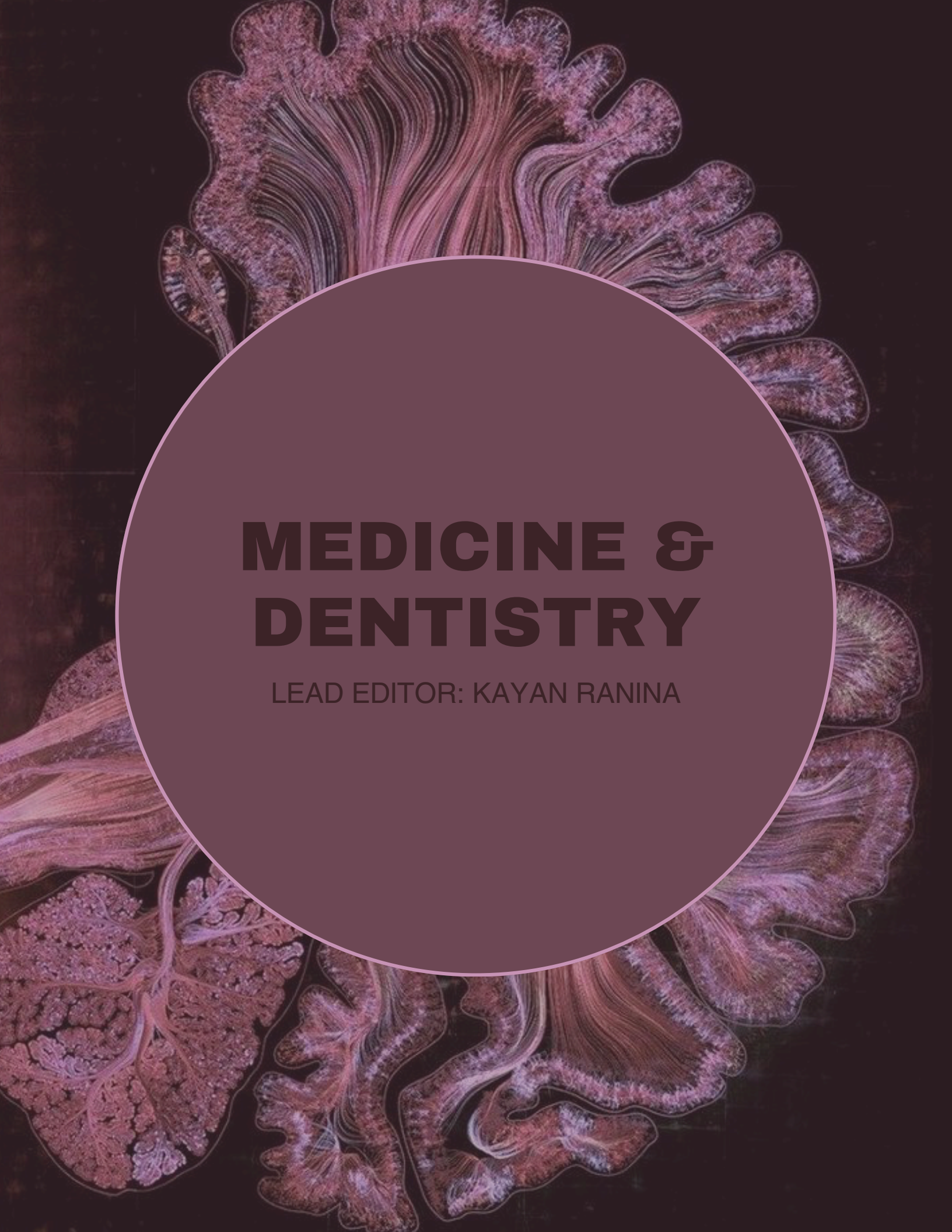
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The background of the entire page is a high-magnification microscopic image of biological tissue, likely a histological section. It shows various cellular structures, including what appears to be glandular or ductal tissue with a central cluster of cells, and surrounding areas with more fibrous or connective tissue. The colors are predominantly shades of purple, pink, and brown, typical of H&E staining. A large, semi-transparent dark purple circle is centered over the image, serving as a backdrop for the text.

MEDICINE & DENTISTRY

LEAD EDITOR: KAYAN RANINA

UNDERSTANDING AIR POLLUTION

WRITTEN BY: YAMIN CHOWDHURY

Air pollution – defined as the presence of **contaminants** in the atmosphere – can have adverse effects on human health. The World Health Organisation (WHO) estimates that air pollution causes 7 million deaths a year. With the growing issue of climate change, more research is being done to investigate how humans will be affected by it. Research conducted within the last 40 years has shown that there is a correlation between exposure to air pollution and contraction of **cardiovascular** diseases, with some evidence suggesting it is a factor in the formation of cancers, **neurological** diseases, and birth defects.

Air pollution is when harmful substances – or pollutants – are dissolved in the air we breathe in. Pollutants can be produced by incomplete combustion or chemical reactions between gases. The most dangerous pollutants are particulate matter (PM), carbon monoxide, ground-level ozone, nitrogen dioxide and sulphur dioxide.

Particulate matter (PM) refers to very small inhalable particles. Their diameters range from 2.5 – 10 micrometres. PM can enter the **respiratory** system and cause irritation to the throat and chest. Long term effects include the risk of heart disease, strokes, non-fatal heart attacks and **neurological** damage (e.g. dementia).

Ground-level ozone is a chemical found in smog – an artificial fog that significantly impacts ground level visibility. It is formed when volatile organic compounds react with nitrogen oxides. More ozone is produced during sunny weather. Inhaling ozone can cause muscles in the airways to contract, causing air to be trapped in the alveoli. This makes it more difficult to breathe, which can result in constant shortness of breath. Other effects include infection and inflammation to the airways. Nitrogen dioxide is a chemical that is produced from the burning of fossil fuels at high temperatures, for example, the burning of petrol in car engines. In children, nitrogen dioxide can cause **respiratory** infections as it can decrease the lungs' bacterial defences. It can also increase the risk of asthma attacks.

Sulphur dioxide dissolves in the air when fuels that contain sulphur – such as coal – are burnt. It can also be produced naturally when volcanoes exhale. Sulphur dioxide can irritate mucous membranes such as the eyes, nose, and throat. It can also cause severe inflammation to the **respiratory** system if inhaled during exercise, as it can more deeply penetrate the lungs. As sulphur dioxide is very reactive, it can react with other chemicals in the air to form small particles which can enter the lungs and have similar effects to PM.

In conclusion, there are many types of air pollution that can cause permanent damage to our **respiratory** systems, with those already suffering from **respiratory** diseases most at risk. Unless the growing problem of air pollution is solved, in the future many of the population will be in danger and the number of deaths due to air pollution will increase.

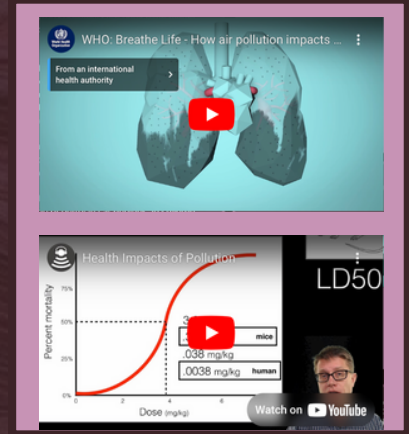
Contaminants – a substance that decreases the purity of something.

Cardiovascular – referring to the heart and blood vessels.

Neurological – referring to the brain, spinal cords, or nerves.

Respiratory – referring to the organs that aid our breathing.

Combustion – the burning of a substance with oxygen to produce a flame.



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EFFECTS OF AIR POLLUTION ON LONG TERM HEALTH

WRITTEN BY: ABDIRAHMAN MAHAMED

Air pollution is a significant environmental threat to long term health, especially due to rapid increases in **industrialisation** within the last couple of centuries. Factors such as **industrialisation**, urbanisation, and deforestation have massively contributed to the increase in **greenhouse gas** emissions, thus negatively impacting our long-term health. Air pollution can lead to respiratory issues, cancer, and a reduced life expectancy

Before the industrial revolution in Britain in 1760, air pollution was not much of a problem since there were few sources of pollution. People primarily used natural materials such as wood for heating and cooking. Despite the fact that burning wood produced smoke and particulate matter, this was inconsiderable compared to later industrial emissions. During this time, the air quality was much better, and the atmosphere was relatively clean, thus causing fewer long term health issues. However, after the industrial revolution, there was a massive increase in sources of pollution, with coal becoming the primary energy source. Burning coal releases lots of sulphur dioxide, particulate matter, and carbon monoxide, which heavily pollutes the atmosphere. This eventually led to an event called 'The Great Smog of 1952', which was one of the most severe air pollution events in British history. This resulted in the deaths of thousands of people over a period of a few days, therefore raising concerns regarding industrial pollution and the development of environmental policies in Britain.

Today, air pollution remains a widespread environmental concern, with adverse effects on human health. According to the World Health Organization, approximately 6.7 million people die annually due to the health impacts of air pollution (1). Unfortunately, the impacts of air pollution will continue to grow alongside increasing **industrialisation**, urbanisation, and transportation. Air pollution can cause many long-term health impacts. Firstly, it can cause cancer – since particulate matter and **polycyclic aromatic hydrocarbons** are considered **carcinogens**. Long term exposure to these will subsequently increase the risk of lung cancer. Moreover, prolonged exposure to air pollutants is associated with asthma, **chronic obstructive pulmonary disease (COPD)** and reduced lung function; these pollutants are able to cause inflammation in the lungs and oxidative stress. Lastly, recent studies have linked air pollution to cognitive decline and **neurodegenerative** diseases such as Parkinson's and Alzheimer's disease. Pollutants can ultimately cause **neuroinflammation** and oxidative stress in the brain.

Evidently, air pollution has numerous consequences on health overtime, which is why many countries have implemented strategies to reduce the effects of atmospheric pollution for example India. Statistics have shown that 12 of the world's 15 most polluted cities are in India. To reduce this, the Indian government have introduced the odd even scheme in (mainly in Delhi) to reduce **greenhouse gas** emissions from vehicles by allowing cars with odd and even number plates to operate on alternating days. This is an effort to minimise harmful emissions and atmospheric contamination, which will consequently improve overall long-term health.

Events which have taken place in history have brought light upon the substantial impacts of air pollution on long term health, accentuating the urgent need for efforts to mitigate its effects through policies, innovations, and public awareness.

Industrialisation – development of industries in a country or region on a wide scale.

Greenhouse gas – gases in the earth's atmosphere that trap heat.

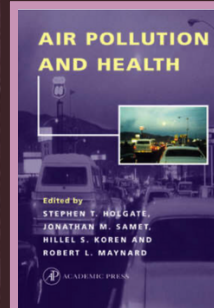
Polycyclic aromatic hydrocarbons – group of chemicals that occur naturally in coal, crude oil, and gasoline.

Carcinogen – a substance capable of causing cancer in living tissue.

Chronic obstructive pulmonary disease – common lung disease causing restricted airflow and breathing problems.

Neurodegenerative – the degeneration of the nervous system.

Neuroinflammation – inflammation of nervous tissue in the brain.



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HOW DOES CLIMATE CHANGE AFFECT HEALTHCARE?

WRITTEN BY: NAATHIM DRSKA

The middle of the eighteenth century sparked the Industrial Revolution- where countries, majorly Britain, concluded that an economy based on **agriculture** and handicraft proved far less profitable than an economy dominated by technology, industry, and machinery. Due to this, an **exponential** growth of industry later spread from Britain in the middle of the nineteenth century to the early twentieth century- finding regions such as North America, Japan, and continental Europe and yet, despite revolutionising international trade and technology, this development posed a consequence. Climate change.

Since 1850, Earth's temperature has risen by an average of 0.06 degrees Celsius- or about 1.02 degrees Celsius in total. However, since 1982, the rate of warming has been three times as fast (0.2 degrees Celsius per decade) and the ten warmest years in historical record have all been in the past decade, (2014-2024). Consequently, people suffer. 3.6 billion people live in areas highly susceptible to climate change, leading to the prediction that by 2030-2050 an additional 250,000 people will die from malnutrition- as a delay in yearly rainfall results in a deficiency in **agriculture**, malaria- as the optimum climate for breeding in mosquitos is enhanced, diarrhoea- due to an increase in water contamination, and heat exhaustion alone. By this time, direct damage costs related to health are approximated to hit between 2-4 billion dollars.

As a result, health organisations- controversially said to have been ignoring dangerous signs of developments of diseases have now been on high alert. Following the recent COVID-19 pandemic, which undoubtedly exposed the vulnerability we have in our health systems, it has been found vital that the development medicine such as vaccinations is prioritised- particularly with climate-sensitive diseases such as malaria. The malaria vaccine has only very recently been approved into usage (2021 RTS vaccine). Since then, mortality rates have been said to be reduced by 13%, with the total deaths in 2022 compared to 2023 remaining stable. While good in theory, the number of deaths per day still sits at over 1600 people. So, why can't we tackle this?

While it is true, medicine is rapidly developing at a beyond impressive rate, healthcare systems major deficiencies are not the medicine, it is the coordination and staffing. Therefore, they have resorted to large scale volunteering- particularly in Central African regions where malaria thrives, to vaccinate as many people as possible. Expeditions involving doctors and nurses have been sent to these regions across the past decades and healthcare systems such as the NHS will continue to do so until there is a certainty that these extreme health conditions- caused by climate change- have been eradicated, not only in Africa but across all continents likewise. East Asian regions such as Indonesia also experience severe consequences which have risen from climate change. Yearly flooding due to a rise in temperature and worsened rainfall impacts economies and people of East Asian regions. The rise in temperature also results in the melting of icecaps- resulting in rising sea levels, which together form the perfect conditions for flooding. This results in conditions such as diarrhoea, **dengue fever**, skin disease and **leptospirosis**, forcing the administration of **antibiotics** and other medicinal substances- negatively contributing to the ongoing crisis of antibiotic resistance. While not on as large of a scale, this is also seen closer to home where majority of Europe has experienced a total of 13.4 billion dollars in damage and suffered from physical injuries such as hypothermia following the floods in Autumn of 2024. Overcrowded and understaffed hospitals were placed under further pressure- as non-priority musculoskeletal injuries in England are placed on a waiting list months long for a much-needed MRI scan.

English hospitals have, in the past decade, been suffering from prolonged waiting lists and delays. A case of this can be seen in the 2019 heatwave, where the highest daily temperature recorded was 38.7 degrees Celsius. 892 people died from heat exhaustion, and thousands were placed in hospitals, unable to withstand the capacity of their patients. Warnings were issued to remain at home in a desperate attempt to reduce to the workload on the hospitals.

To conclude, while the development of medicine remains important in tackling the effects from climate change, it is vital that we maintain the workload required to manage these cases of disease and illness and work together as a community to reduce the stress we have placed on our health organisations.

Agriculture – the science or practice of farming.

Exponential – becoming more and more rapid.

Dengue fever – a viral infection that spreads from mosquitos to people.

Leptospirosis – a bacterial infection that affects humans and animals.

Antibiotics – medicines that fight bacterial infection.



LIFE SCIENCE

LEAD EDITOR: JASMINE CAMPION

THE TINY PLANTS THAT COULD END CLIMATE CHANGE

WRITTEN BY: LEWIS WHITEHEAD

This article explores the potential uses of a variety of algae to help minimise or even stop the negative effects of climate change. A specific focus is placed on brown algae and its highly promising potential as a form of **carbon capture**, also providing inspiration for a synthetic version of this **carbon capture**.

During the rush to find ways to reduce **carbon emissions** and plastic pollution, billions of pounds and thousands of hours have been invested into coming up with new and innovative solutions to help reduce the effects of climate change. However, often research has overlooked the simpler and already present solutions that reside in the natural world, many of which have massive potential to help in several different areas. One of the most promising of these solutions is the use of algae, a group of simple, mostly aquatic plants with the potential to change the world.

Just like most plants, Algae photosynthesise, turning carbon dioxide into oxygen in a vital reaction that allows life on earth to continue. Many people are aware of how important **photosynthesis** is in the battle against climate change, with trees being a focus due to their high rate of **photosynthesis** proportional to their size. However, trees take decades or even centuries to grow to peak **maturity**, leaving many concerned over whether trees planted now will have reached sufficient **maturity** to combat climate change before it is too late.

One group of algae known as **microalgae** have a unique solution to this concept that has intrigued many scientists. **Microalgae** are single celled, and this causes them to **mature** in a matter of hours instead of decades, rapidly spreading across their aqueous habitat. While an individual microalga absorbs nearly no carbon dioxide, large colonies with trillions of individuals can appear quickly when food is present, easily photosynthesising enough to be compared to a small forest. Due to this faster return, some scientists have begun experimenting with these algae in **industrial settings**. One such **microalgae**, known as brown algae, converts much of its absorbed carbon dioxide into a thick mucus which is extremely efficient at storing carbon dioxide. This mucus is relatively stable and difficult to break down, meaning it could be stored for long periods of time, emphasising its viability as a potential solution to rising atmospheric carbon dioxide levels. In the wild, brown algae store a staggering 550 million tonnes of carbon dioxide a year, almost equal to Germany's annual greenhouse gas emissions. The mucus, known as **fucoidan**, is extremely complicated but stores no nutrients for the algae itself, meaning it can be removed from the colony without hindering its growth.

These plants, especially brown algae, show remarkable potential in the battle against climate change, possibly being one of the most effective methods of carbon capture available right now. If explored further, it may allow us to minimise the effects of climate change before it reaches a point of no return. Other algae also have potential uses beyond carbon storage, for example as a food for people or livestock, biofuels or turning barren fields into fertile farmlands by fixing nitrogen. Overall, these fascinating plants may allow us to preserve the planet and its natural beauty, not just helping us but the entire planet.

Carbon Emissions: The release of carbon dioxide (CO₂) and other gases into the atmosphere, mostly from burning fossil fuels like coal. These trap heat and contribute to global warming.

Photosynthesis: A natural process used by plants, algae, and some bacteria to turn sunlight, carbon dioxide, and water into oxygen and food

Microalgae: Tiny algae, too small to see with your eyes, that live in water. They grow quickly and are important for absorbing carbon dioxide and producing oxygen.

Industrial Settings: Places where large machines, factories, or technologies are used to produce or process things, like manufacturing goods or capturing carbon.

Mature/Maturity: When a living thing grows fully and reaches the point where it can do what it's meant to, like a tree producing seeds or algae being able to reproduce rapidly.

Fucoidan: A sticky substance made by brown algae. It stores carbon dioxide in a way that keeps it from going back into the air.

Carbon Capture: A way to trap and store carbon dioxide so it doesn't contribute to climate change. Algae and some technologies can do this naturally or artificially.

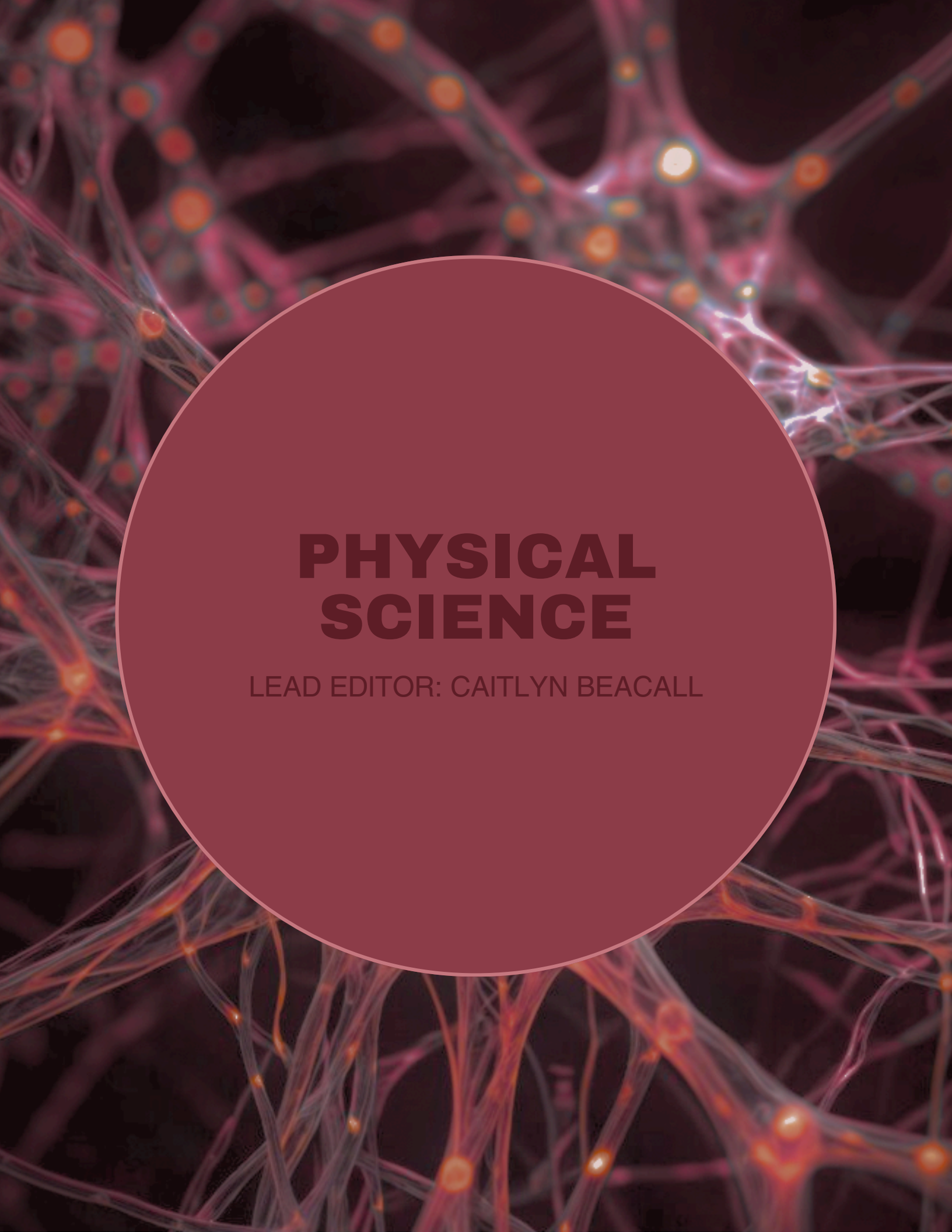
Nitrogen Fixing: A process where plants or algae take nitrogen from the air and turn it into nutrients that help soil become healthier for farming

Furoid brown algae inject fucoidan carbon into the ocean



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PHYSICAL SCIENCE

LEAD EDITOR: CAITLYN BEACALL

THE PHYSICS BEHIND THE GREENHOUSE EFFECT

WRITTEN BY: JAMES HACKETT

To explore the physics behind the greenhouse effect, first we should explore what the greenhouse effect is itself. NASA states: “The greenhouse effect is the process through which heat is trapped near Earth's surface by substances known as 'greenhouse gases.'”(1). This effect has been determined to be the driving factor behind climate change and is the subject of COP29. But how does the greenhouse effect work?

Our atmosphere consists of a mixture of gases: ~78.08% nitrogen, ~20.95% oxygen, 0.93% argon, and ~0.04% carbon dioxide. (2) Gases such as carbon dioxide, methane and water vapour are ‘greenhouse gases’ – gases that act to retain the heat of the atmosphere, as the molecules of these gases absorb and re-emit radiation, effectively reflecting heat from the earth back, acting like a blanket around the earth.

One question asked by many students learning about the greenhouse effect initially, is “If greenhouse gases can ‘reflect heat’, why don’t they reflect the heat from the sun back into space, at the same rate as back towards Earth?”. The explanation given in GCSE physics is that the light from the sun is composed of short wavelength light and the earth emits long wavelength light, which the atmosphere can absorb (3). However, this doesn’t represent the whole picture.

The sun actually emits light of all wavelengths, but only 54% of solar radiation passes through the atmosphere (4). The earth emits infrared radiation, roughly 90% of which is absorbed by the atmosphere, and 85% is then re-emitted back to the earth (4).

The differences in absorption is due to how greenhouse gases absorb radiation. Carbon dioxide strongly absorbs radiation at a radiation around 15 μm (5), in the infrared range. Wavelengths above this value tend not to be absorbed at such a high rate, and ~51% of solar radiation is outside of the infrared range (6)

Why 15 μm ? Carbon dioxide absorbs energy from radiation, as its molecules can vibrate, storing energy. These vibrations have a **resonance frequency**, and incoming **photons**, that have a frequency higher than the **resonance** frequency can be transmitted more efficiently through the greenhouse gases, leading to a lower absorption rate, for waves such as ultraviolet. (7)

The energy then absorbed by these molecules is re-emitted into space, or back down to earth, the overall effect being that they re-emit 340.3J of energy per second per metre squared (4), (causing net 0.6 Wm^{-2} of overall absorption) increasing the overall temperature of the earth.

This in and of itself is not necessarily a bad thing; without the greenhouse effect, Joseph Fourier predicted that it would be around -18°C (8), meaning all water would be frozen, and humanity likely wouldn’t exist. The problem is the enhanced greenhouse effect, where more greenhouse gases are put into the atmosphere, increasing the rate of absorption of radiation, as more molecules are there to do so, causing a more intense effect on temperature, global warming, and climate change, as a consequence. COP 29 aims to address this problem, and prevent further increase in the effect.

μm – a micrometer (1 millionth of a metre)

Resonance frequency – the frequency at where a medium vibrates at the highest amplitude (9)

Photon – a particle of light



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WHAT IF WE COULD HARNESS THE POWER FROM THE SUN: IS NUCLEAR POWER THE WAY TO GO?

WRITTEN BY: BRYONY COOK

What we have used for energy over the years has changed drastically. From fire during the medieval period to oil lamps during the Victorian era. Then, with the industrial revolution came steam engines and motors forcing us into burning coal and gas. Since then, we have seen the devastating effects of our (at the time) scientific genius and now new geniuses are working on our next breakthrough to change the world of energy yet again.

So, what really powers the sun? At the start of the universe all there was were clouds of gas and dust, these clouds condensed and the particles started to collide into each other and at the high temperatures and pressures reactions started to occur. This is known as nuclear fusion – the process in which smaller lighter **nuclei** join together to make larger **nuclei**. This is typically hydrogen **nuclei** as they are the lightest. Here on Earth, it is difficult to recreate the high temperatures and pressure and maintain that **plasma** state and so instead of nuclear fusion we currently use nuclear fission. Nuclear fission occurs when neutrons typically from a uranium nucleus are fired into and collide with another uranium nucleus. This causes the nucleus to split into two daughter **nuclei** and more neutrons which go off and repeat the process.

Nuclear energy has both positives and negatives. Fission produces carbon free energy which means that it is not increasing the greenhouse effect. Unlike other clean energy it is reliable as it isn't dependent on the weather conditions of that day and so it can be used for longer periods making it better for high energy consumption. However, there are still many negatives to fission. Nuclear fission produces waste that is highly toxic for a long time, this means that it has to be stored **meticulously** and permanently otherwise it could cause detrimental impact on the environment and humans. Not only that but it is a time consuming and expensive form of energy; all the planning, firing up and storing of waste materials makes the process of setting up a nuclear reactor incredibly complicated. But all hope is not lost as scientists across the world are looking into the breakthrough of nuclear fusion technology and our ability to harness its power.

Since Arthur Eddington first suggested we could gain energy from the formation of helium atoms from the fusion of hydrogen atoms in the 1920s, physicists have been exploring the power of nuclear fusion. Nuclear fusion is the process that started the sun and can produce up to 4 million times more energy per kilogram of fuel compared to coal or oil. For a while scientists were struggling to replicate the conditions on the sun, the high temperatures and pressure. On earth we need higher temperatures to compensate for the lower pressure and so scientists had to produce a machine that would be able to reach these unimaginable temperatures. Once they had cracked that the next big problem was producing more energy than the energy they were using. On the 13th of December 2022, scientists at the National Ignition Facility in the US managed to do just that. They had produced more energy than the energy used by the laser pulse that heated the fuel. This major breakthrough means that we are one step closer to having nuclear fusion energy on an industrial scale. This would come to produce more efficient and cleaner energy creating hope for the future.

With the new breakthroughs yet again starting a chain reaction, the battle with climate change is far from over.

Nuclei – the plural of nucleus (the centre of an atom).

Plasma - the 4th state of matter where electrons are delocalised from their atoms.

Meticulously – with great care and attention to detail.

What is nuclear fusion? | IEAE

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MATHEMATICS OF CORAL BLEACHING

WRITTEN BY: HUNSIL BHATT

Coral reefs, often referred to as the “rainforests of the sea,” are among the most biodiverse ecosystems on Earth. However, due to coral bleaching- a phenomenon driven by rising sea temperatures, they are under increasing threat. This occurs when stressed corals expel the **symbiotic algae**, zooxanthellae, which provide them with nutrients and vibrant colours. Mathematical models offer a critical lens to study the thermal tolerance thresholds of coral reefs and predict future bleaching events under various climate scenarios using statistical thresholds and **differential equations**.

Understanding Thermal Thresholds

Coral bleaching is primarily triggered when a coral species' **thermal threshold** is exceeded by water temperatures for an extended period. To analyse these thresholds, statistical methods like regression analysis are used to correlate temperature anomalies with historical bleaching events (Hughes et al., 2017). By modelling this relationship, critical thresholds are identified and measured in degreeheating weeks, which quantify cumulative thermal stress. For instance, a DHW value of 8 indicates that the water temperatures was 1 degree C above the threshold for 8 weeks, a level likely to cause significant bleaching. Such statistical insights enable areas most at risk of bleaching under future warming scenarios to be forecasted.

Modeling Algal Symbiosis Breakdown

The symbiotic relationship between corals and algae is governed by complex biochemical interactions.

Differential equations can model these dynamics, capturing the rates of nutrient exchange, thermal stress, and algal expulsion (Anthony et al., 2011). For example, a system of coupled ordinary **differential equations** (ODEs) can represent the coral's health as a function of algal density and external stressors. By solving these equations under varying temperature conditions, researchers can simulate how quickly corals enter a bleaching state. Such models highlight how even the slightest temperature increases can destabilise this delicate balance, leading to widespread bleaching.

Spatial Modeling of Bleaching Patterns

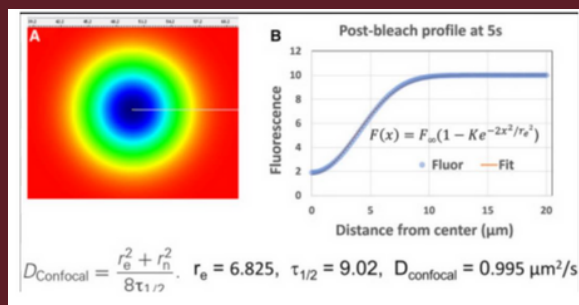
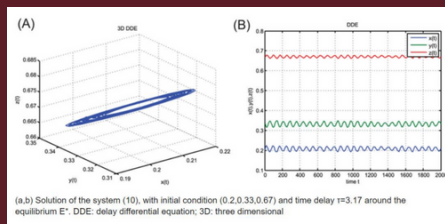
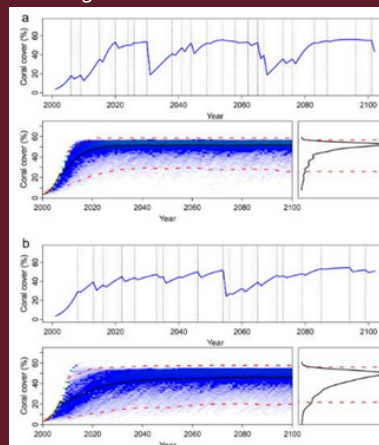
Bleaching events are not uniform; their spatial distribution depends on local environmental factors such as water depth, current patterns and pollution levels. Mathematical tools like geostatistics and partial **differential equations** (PDEs) are employed to study these spatial variations (Van Hooijdonk et al., 2013). PDE-based models simulate heat transfer within reef ecosystems, revealing how deeper reefs might act as thermal refuges. These models also incorporate feedback mechanisms, such as how coral mortality affects local water quality, further exacerbating bleaching risk.

Further Implications and Conservation Strategies

Mathematical models are instrumental in informing conservation strategies. For instance, they can identify “resilient reefs” that are less susceptible to bleaching due to favorable thermal conditions. Such areas can be prioritized for protection under marine conservation policies. Additionally, models can test the effectiveness of interventions like artificial shading or assisted evolution of thermally tolerant coral species (Baskett et al., 2015). By integrating climate projections into these models, policymakers can design targeted actions to mitigate the impacts of climate change on coral reefs.

Conclusion

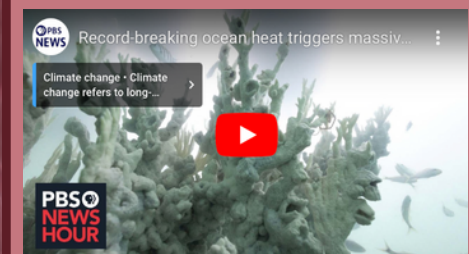
The mathematics of coral bleaching offers a powerful framework to understand and combat one of the most pressing challenges facing marine ecosystems. From identifying **thermal thresholds** to modelling spatial dynamics, mathematical tools provide actionable insights into how corals respond to warming oceans. As climate change accelerates, these models will play an increasingly critical role in safeguarding the future of coral reefs and the biodiversity they support.



Symbiotic algae – algae that has a mutually beneficial relationship with the coral.

Thermal threshold – maximum temperature a coral can tolerate.

Differential equations – equation involving an unknown function



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HOW ARE CLIMATE MODELS AN INNOVATIVE NEXT STEP TO CLIMATE SECURITY?

WRITTEN BY: ISAAC LEVETT

COP29 is a summit which aims to help reduce carbon emissions and create a more sustainable world for many generations to come by crafting evidence-based strategies to combat climate change. These schemes are introduced by scientific minds relaying **predictions**, data and effective strategies to introduce the correct measures. So how do these scientists obtain the most accurate and **plausible predictions** for our planet's climate. In this article, I will discuss the use that scientists have for climate models and how they impact decision making at a global scale.

The largest threat facing us today is not nuclear weapons or another pandemic, but our climate. Over the past 130 years, humans have recorded the global temperature of our planet, and as of the last 60; we have measured the warming oceans, carbon dioxide release, rising tides and plastic pollution (1). It's important to find the cause of these devastating realities and make sure to limit them. This is why looking back at the past is so important to find the cause of each of the world's problems. But how can we look into the future with this incredible hindsight and put an end to these mistakes before they even started. In this article I will be discussing the importance of climate models for predicting the future course of our planet and they're use for the COP29 summit.

Climate models are realistic simulations of our world that predict our climate **trajectory** and simulate weather patterns over time from physical laws like the conservation of energy as well as analysing a large range of interactions between different variable:

- . the atmosphere
- . oceans
- . **greenhouse gases**
- . land use changes
- . pressure

Not only do these climate models help to provide a comprehensive picture for the future of climate change globally, but they also provide insight and understanding to the consequences of human action across the world. However, they fail to show the more regional impact of climate change. Generally, regional climate model are better at illustrating how our agriculture and sea levels may change which will be more likely to affect common people rather than by observing the global scale by considering local **topography** and soil type (2).

One of the world's most complex and powerful climate models come from the Coupled Model Intercomparison Project (CIMP), created as a collaboration between climate scientists worldwide to save the climate. The current version is known as CIMP6 which was published in 2016. The newest iteration of CIMP (CIMP7) has begun its early stages of development, and has promised to produce improved simulation of extreme weather events and greater representation of feedback loops such as **carbon cycle dynamics**. These improvements allow for increased regional **predictions** to identify vulnerabilities for **droughts** and areas likely to experience flooding (3). The Earth's climate has presented itself as being far too complex to simulate for even the most powerful of climate models. You may have experienced this when you check the weather app for an outing that is predicted to be sunny skies and come the day, the **prediction** was far off.

Our climate models aren't just applicable to the weekly forecast! They can also predict the future climate for many years to come, making them crucial to policy makers as they provide critical insight for designing pathways to achieve **net 0**. By taking in **variables** such as renewable energy deployment and limiting of fossil fuels, it is possible to find the most efficient and cost-effective methods to introduce globally. CIMP is used most predominately at the Intergovernmental Panel on Climate Change (IPCC) (4) being the United Nations body for assessing science related to climate change, showing their effectiveness and importance when saving our climate (5).

Just like all **predictions**, they are never perfect, which is why it is so important to continually enhance our technology and understanding into our climate models. The new systems being researched by so many other companies involve integrating quantum physics to save energy on energy intensive models (6) and more accurate **predictions** with radiation interacting with the planet's atmosphere (7). By introducing modelling into climate strategies, these new technologies provide a scientific base for transparency and accountability within the government sector to help shape a **net 0** future.

Plausible – An argument or statement that is seemingly reasonable or probable

Predictions – Something that is predicted or forecasted to happen

Trajectory – A path that an object is expected to follow

Greenhouse gases – Gases in the Earth's atmosphere that traps heat

Topography – The study and description of physical features in an area

Carbon Cycle Dynamics – A situation in which the total amount of carbon entering a store is balanced by the total amount of carbon leaving.

Droughts – A prolonged period of abnormally low rainfall. Leading to a shortage a water

Net 0 – A balance between the amount of greenhouse gases being put into the atmosphere and the amount being removed

Variables – An element, feature, or factor that is liable to vary or change

[AQ-PINNs: Attention-Enhanced Quantum Physics-Informed Neural Networks for Carbon-Efficient Climate Modeling](#)

[Improving global high-resolution Earth system model simulations of precipitation with generative adversarial networks](#)

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ENGINEERING & TECHNOLOGY

LEAD EDITOR: MIHIR KANDI

SOLID STATE BATTERIES

WRITTEN BY: ABHY GUPTA

Since the conceptualisation of the first electric vehicles (EVs) in the 1900s, the automotive industry has seen a vast majority of manufacturers in competition to create more efficient, environmentally friendly alternatives to the **internal combustion engine (ICE)**. While EVs aim to reduce their environmental impacts, challenges remain, particularly in the renewability of the production process and energy sources used. Recent advancements in solid-state batteries (a greener alternative to lithium-ion batteries) offer many benefits compared to the counterpart and signal a promising step towards greener transport.

The versatility of lithium-ion batteries spans across many sectors, powering technologies from phones and toothbrushes to personal vehicles. However, the wide-ranging applications of lithium-ion batteries have significantly increased demand for lithium, far surpassing the limited supply. To obtain lithium, and all the other metals that are compounded to make a battery, suppliers must extract it from ores deep beneath the surface, which has severe environmental repercussions. Vegetation and habitats are cleared to open mines, after which miners use harsh acids and chemicals to **corrode** the **ore**. This process risks runoff into nearby rivers or streams, polluting water sources that may serve as drinking water.

After extraction, heavy-duty machinery is used to transport these materials for export, generating substantial **carbon emissions** via land, sea, and air vehicles. Ironically, the lithium used in efforts to reduce **carbon emissions** from **internal combustion engines** can produce up to double the emissions during production. This statistic highlights growing concerns about the environmental impact of EVs and their power sources, emphasizing the need for more sustainable solutions.

One promising innovation in EV power sources is the solid-state battery. While like lithium-ion batteries in concept, solid-state batteries differ significantly in their use of a solid electrolyte rather than a liquid one. In a lithium-ion battery, a liquid-based electrolyte facilitates the movement of lithium ions between the battery's positive and negative terminals. A separator prevents the liquids from mixing, but this liquid poses significant risks: overcharging generates heat that cannot dissipate, leading to a cycle of heat buildup. This can cause fires, explosions, or the release of toxic vapours.

Previously, no solid material could effectively replace the liquid electrolyte, but advancements in materials such as ceramics and bio-polymers have enabled the development of solid-state batteries. These batteries provide several advantages, including a substantially higher energy density, allowing them to store more energy in the same space. This improves EV range and performance, as solid-state batteries degrade less over time compared to lithium-ion batteries.

Despite these advancements, solid-state batteries are not without challenges. Their production is complex and expensive due to the diverse materials required for the solid electrolyte. While they have fewer environmental repercussions than lithium-ion batteries, the production process remains resource-intensive. Furthermore, despite their longer lifespan, recycling solid-state batteries poses significant challenges.

Solid-state batteries represent a step toward a more sustainable future for the automotive industry. However, their adoption depends on addressing these production and recycling challenges. As the EV industry evolves, innovations like these reflect ongoing efforts to reduce environmental impact while balancing efficiency, cost, and sustainability.

Internal combustion engine – a type of engine where energy is generated by igniting fuel causing gas to expand, pushing a piston up and down which in turn drives the wheels

Corrode – a process that causes the surface of a material to gradually wear away

Carbon emissions – the release of carbon containing gases such as carbon dioxide into the atmosphere

Ore – natural occurring minerals or rocks that contain valuable substances

Dodge Chargers with semi-solid-state batteries may hit the road in 2026

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THE ENGINEERING MARVELS OF JAPANESE FLOOD DEFENCES AND HOW THEY COMBAT CLIMATE CHANGE

WRITTEN BY: GERRARD ROBERTSON-MCCAFFERY

In this article, I will be talking about the marvels of ingenuity that the Japanese have created to withstand terrible typhoons and intense flooding. Through this, I will be going into depth about how they were made and how they continue to improve these designs as well as some prominent examples.

The main innovation of Japan's flood mitigation systems is the use of complex engineering, and a colossal network of underground tunnels designed to hold over 67,000 cubic meters of water. At capacity, the water can flow at 200 cubic metres per second! This network of tunnels is called the "G-Cans Project" and **culminates** in a massive cathedral designed to hold the massive **deluges** of water that hit the nation's biggest cities each year. These projects are a part of an initiative from the Japanese Ministry of Land, **Infrastructure**, and Transportation where they have spent large sums of money to create some of the most sophisticated systems for flood mitigation in the world. This massive "Cathedral" officially called the Metropolitan Outer Area Underground Discharge Channel, took 13 years and 230 billion yen (\$1.63 billion) to build. Since coming online in 2006, it has already prevented more than 150 billion yen in flood damage, the land ministry estimates.

This massive Cathedral sits as the crowning achievement of Japan's national flood defence network. It's an enormous water tank supported by dozens of 500-tonne, steel-reinforced pillars, situated 22 metres under the city streets of Tokyo. Costing \$2bn, the MAOUDC (Metropolitan Area Outer Underground Discharge Channel) is part of a huge investment in disaster reduction which Japan has been undertaking since the 1950s and is **testament** to the city's proactive approach to managing flood risk in its densely populated environment. The huge tunnels were made using great tunnel **boring** machines with the tunnel walls being made from reinforced steel and concrete with an anti-corrosive paint to prevent rust and excessive need for maintenance. The large concrete segments were joined together with a wedge method developed on the principle of wedging instead of bolting which made the tunnel smooth with the method being developed by several Japanese companies.

Much can be learnt from these monolithic projects that display the ingenuity and fortitude of the Japanese people in their fight against climate change, most notably how we can reduce the impact of the large-scale storms that have recently battered Wales and left thousands of people's homes being flooded and washed away. This kind of **infrastructure** could help stem the tide of massive flood water **deluges** and reclaim flood lands that would normally be uninhabitable due to the proximity to swamps or annual flood areas.

Overall, this marvel of engineering is a perfect example of how humanity has begun to fight back against climate change's perils that threaten to cast great cities underwater.

Deluge – a severe flood
Infrastructure - the basic physical and organizational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise
Testament - something that serves as a sign or evidence of a specified fact, event, or quality
Boring - make a hole in something, especially with a revolving tool
Culminates - reach a climax or point of highest development

[The UN website on what Climate Change is and how it is impacting people across the globe.](#)

[How countries facing similar problems have been dealing with flooding as a result of Climate Change.](#)

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BRIGHTENING THE FUTURE

WRITTEN BY: JASMINE CARTER

Marine Cloud Brightening, a method of solar radiation management, enhances the natural cooling effect of **marine stratocumulus clouds**. This is achieved by increasing their reflectivity, resulting in more sunlight being reflected into space. This causes a measurable reduction in the amount of solar energy reaching and heating the Earth's surface to try and mitigate the effects of global warming due to the burning of fossil fuels.

Climate change is one of the most pressing challenges that our planet is facing, driven by rising greenhouse gas emissions that trap heat in the atmosphere. This has been the cause of melting ice caps, rising sea levels, more **adverse weather** events, and significant damage to ecosystems worldwide. With global temperatures rising, the need for **innovative** solutions has never been greater. Engineers are encouraged to innovate short-term solutions like this to complement long-term solutions – such as reducing carbon emissions. Cloud brightening utilises the concept of radiation theory. In the same way that people are encouraged to wear light clothing on a sunny day to stay cool, scientists can alter some of the physical properties of clouds with the aim of reflecting more sunlight back into space. The resultant reduction in solar energy reaching the Earth's surface also reduces the amount of heat trapped in the atmosphere by greenhouse gases.

Clouds are formed when excess water vapour starts to condense, however water vapour cannot undergo this process without a surface to condense onto. These surfaces are tiny atmospheric particles called aerosols or cloud condensation nuclei (e.g. sea salt, dust, soot and pollution particles). Sea salt particles are chosen as the primary aerosol because they are naturally occurring in marine environments. Special equipment (such as drones, specialised ships, or turbines) sprays the fine sea salt particles into the atmosphere over the target regions – areas with high **marine stratocumulus cloud** cover. Once in the atmosphere, the sea salt particles act as cloud condensation nuclei. Water vapour condenses onto these particles, forming new water droplets or increasing the number of droplets in existing clouds. With more cloud condensation nuclei in the atmosphere, the same volume of water is distributed among a larger number of droplets. This results in smaller, more reflective water droplets, which enhance the cloud's brightness, and therefore the **Earth's albedo**. The brighter clouds reflect more sunlight back into space. This reduces the amount of solar energy that reaches the Earth's surface, contributing to a localised cooling effect.

Cloud brightening has many benefits, such as: slowing the Arctic ice melt; coral reef retention despite rising temperatures; reducing severe weather effects and preventing prolonged heatwaves.

On the other hand, there are some concerns with this newly engineered technique. Until cloud brightening is used and monitored on a larger scale, it is possible that there would be some unintended consequences, such as disruptions to weather patterns or rainfall. Also, it is crucial that temporary, **stop-gap** efforts do not replace long-term measures or reduce the urgency to cut greenhouse gas emissions.

Now more than ever, it is vital that short-term measures like cloud-brightening are being developed to provide a brighter future for generations to come.

Marine stratocumulus clouds – low-lying clouds over oceans that naturally reflect sunlight

Earth's albedo – much incoming solar energy, or light, is immediately reflected back into space

Adverse weather – bad weather that could cause harm or damage

Innovative – featuring new methods; advanced and original

Stop-gap – a temporary way of dealing with a problem

Effects of sea salt on atmospheric chemistry



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THE BEST WAY TO PREDICT THE FUTURE IS TO CREATE IT

WRITTEN BY: MAC MANTHATA

The start of November welcomed the annual conference of the parties, COP29, taking place in Baku Azerbaijan. Each year, membered parties meet up in a selected host country to discuss efforts to a greener future amidst the current global climate crisis. The point of emphasis this year was finance delegation in respect to climate action (2). Developing regions provide opportunities for the implementation of **sustainable** innovation. Developing countries contrast the built-up urban environments of developed countries which rely on unrenewable energy whilst emitting excessive amounts of pollutants. With COP29 focusing financial support to developing regions, this opens an opportunity for a new, **sustainable** approach to a modern style **urbanisation** in developing countries like Ethiopia where we will see how innovation is working towards a **net-zero** urban landscape.

Addis Ababa is the capital of Ethiopia and is one of the only cities in Africa with a plan to reach a **net-zero** landscape (1). While specifics on developments in Ethiopia's urban landscape are vague, implementations of **sustainable** energy, **efficient** transport, smart infrastructure and green spaces are key when considering how Addis Ababa can reach a **net-zero** emissions goal (3). Solar energy is captured through panels of **photovoltaic cells** from sunlight and turned into usable energy solutions. Ethiopia, much like most of Africa, is blessed with a high potential of 5.5 to 6.5 kWh/m² per day of sunlight (4). With decreasing costs of sourcing photovoltaic panels, this could be a major opportunity for Ethiopia to substitute renewable energy in their plan for **sustainable** cities (4). Ethiopia is already known to rely on hydropower which accounts for more than 90% of the energy it produces (4). The combination of these renewable sources can be a big step in reaching **net-zero**, but for a developing country however, complete reliance on hydropower and solar energy can also present a challenge of the energy output being affected by climate variations (4).

Efficient transportation in Addis Ababa is another focus when working towards reaching a **net-zero** urban landscape. The transport sector is one of the highest emitting sectors globally accounting for 23% of CO₂ emissions(6). Electric Vehicles (EVs) are marketed alternatives, but this comes with considerations of investing in new infrastructure like EV charging stations. Well-developed public transport systems prove vital in countries like the Netherlands where electric transport has been **sustainable** since 2017 with all trains running on green electric energy and buses set to be emission free by 2030 (5). A developing economy like Addis Ababa can benefit from providing a secure travel means which is powered from **sustainable** energy.

Smart infrastructure is a golden opportunity in designing a **sustainable** city. In our ever-innovating society, green material options are constantly being developed to produce the same or even greater building efficiency with much lower environmental impacts. A modern **sustainable** material is cross-laminated timber (CLT) having low carbon emissions during production and an active ability to store carbon throughout a building's lifetime (7). Along with the appropriate design and plan for construction, featured green spaces integrated into urban buildings and cityscapes will reduce CO₂ emissions from reaching the **stratosphere** through the basic principles of photosynthesis. Addis Ababa should aim to build a city that lives in harmony with the natural landscape instead of apart from it to limit harming it.

Addis Ababa has a set vision to develop its city without the sacrifices to environmental factors which most current developed countries have built their economies and cities upon. Currently, the detriment is that the world is trying to reduce a problem without letting go of its economic stability, but when the impact to the environment is as dire as it has become, momentous change must take place to have a future of stability. For Addis Ababa, the best way to predict the future is to build it

Sustainable: The ability to last over a long period of time.

Urbanisation: To make an area more urban through population increase, construction and developments.

Net-zero: To reach a level which balances out the effects previous by humans upon the climate.

Photovoltaic cells: A technological device which converts sunlight into electricity.

Efficient: The ability to reach the most productivity with the least amount of wasted energy.

Stratosphere: A layer of the Earth's atmosphere which is around 50km above its surface.

Solar Energy Basics



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FOR READING!**

