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A High School Climate Science Curriculum
outlined in four units (2011)

Text Book: Kump, Kasting and Crane, The Earth System, 3rd Edition, Prentice Hall 2010

Required Chapters:
1 : Global Change
2 : Daisyworld: An Introduction to Systems
3 : Global Energy Balance: The Greenhouse Effect
4 : The Atmospheric Circulation System
5 : The Circulation of the Oceans
6 : The Cryosphere
8 : Recycling of the Elements: Carbon and Nutrient Cycles
12 : Long-Term Climate Regulation
14 : Pleistocene Glaciations
15 : Global Warming, Part 1: Recent and Future Climate
16 : Global Warming, Part 2: Impacts, Adaptation, and Mitigation

Cross Cutting Themes:
Budgets reservoirs and transports (hydrological and carbon cycles, heat budget, models)
Time Scales (past present and future, seasonal, solar variability, ice ages, paleo, future change)
Spatial Scales: Global vs. Local (seasonal cycle, glacial, future changes)
Math/Statistics

Five Units (30 weeks)
1. Introduction (1 week)
2. Global Energy Budget + Transport (7 weeks)
3. Natural Variability (6 weeks)
4. Anthropogenic Influences on Climate (10 weeks)
5. Climate Impacts (6 weeks)

Unit One: Introduction (1 week) Reading from Kump: Chapter 1

A. Students are oriented to climate science & climate change
B. Assessment of students' current understanding of climate change science
C. What is science? What distinguishes scientific knowledge? How do we know what we know? (scientific enterprise)

Unit Two: Global Energy Budget + Transport (7 weeks) Reading from Kump: Chapters 2-5

Addresses

I. Radiation Budget
II. Energy Transport
III. Regional Climates

IV. Greenhouse Gases

Opening Climates Question

- Question: Why are the Pacific Northwest and other regional climates the way they are?
- Project: Students explain a regional climate, drawing on their understanding of global energy balance and transport

A. Systems and Cycles (1 week) (Ch. 2)
  a. Introduce budgets
  b. Interactions in complex systems (e.g. feedbacks, forcings and response) using simple models
    i. Daisy World
    ii. Simple climate model in excel

B. Global Energy Balance and Greenhouse Effect (1.5 weeks) (Ch. 3 and 4)
  a. Longwave (blackbody) and shortwave (solar radiation) calculations.
  b. Activity demonstrative absorption of infrared radiation.
  c. Energy balance calculations, adding in varying amounts of greenhouse gases.

C. Energy Transport (1.5 weeks) (Atmosphere Ch. 4 and Oceans Ch. 5)
  a. Poleward movement of air and water
  b. Circulation demonstrated in a terrarium
    i. Why does air/water move at all? (Temperature and pressure gradients)
  c. Hadley Cell Lab using NASA's MERRA reanalysis data
    i. Hadley circulation, ocean heat transport
    ii. Reading vector plots

D. Feedbacks (1 week) (Ch. 3, Ch. 6, Ch. 14)
  a. Ice-albedo feedback
  b. Water vapor feedback
  c. Lapse rate feedback
  d. Positive and negative cloud feedbacks
  e. Relationship between stability and uncertainty
    i. Activity: Demonstration of Atmospheric Dynamics: effects of rotating earth on flow

E. Culminating Regional Climate Project (2 weeks)

- Explain regional climate using energy transport and radiation balance. Compare with other climates, and explain differences

<u>Unit Three: Natural Variability (6 weeks)</u> Reading from Kump: Carbon Cycle Ch. 8, Long-term climate regulation, Ch. 12, Pleistocene glaciations, Ch. 14, and Volcanoes, Ch. 15

Addresses

I. Short timescale variability
II. Long timescale variability
III. Natural carbon cycle

Opening Timescales Question (.5 week)

- Question: What did western North America look like millions of years ago, during the last Glacial Maximum, and before the Industrial Revolution? How do you know?
- Project: Students use proxy records and instrumental records to reconstruct North American climate during different time periods. For any unavailable data, students propose a research plan for how new records could be obtained

A. Short-term climate variability (1.5 weeks)

  a. Climate v. weather
    i. Activity: Investigate trends from instrumental data in Excel
  b. ENSO
  c. Volcanoes (Ch. 15)

B. Millennial Climate Variability (1 week)

  a. Recent ice ages (Ch. 12)
    i. Activity: Gather ice core data and plot 800,000 years of CO_2
  b. Milankovitch cycles (with interactive videos)

C. Long-term climate variability (2 weeks)

  a. Plate Tectonics
  b. Equilibrium Carbon Cycle (Ch. 8)
    i. Reservoirs and movement of carbon

D. Culminating Project (1 week)

- Student groups draw on knowledge of instrumental records, the appropriate use of different proxy records, and paleomodels to investigate a paleomystery

Unit Four: Anthropogenic Influences on Climate (10 weeks) Reading from Kump: Arctic Sea Ice, Ch. 6; Global Warming, Ch. 15, Sea level rise in Ch. 16, IPCC Resources

Addresses

  I. Anthropogenic Greenhouse Gases
  II. Evidence of Warming
  III. Model-predicted Warming
  IV. Fate of CO_2; Link between burning of fossil fuels, GHG and acidification of oceans, leaning on what they have learned in chemistry and biology classes

Opening Anthropogenic CO_2 and Climate Change Question (1week)

- Question: How are humans influencing climate?
- Project: Students choose a topic (glaciers/snow lines, ocean uptake, atmospheric CO_2 + temp, sea level rise) and investigate evidence for anthropogenic climate change. Students construct an IPCC consensus-like report that provides the class' consensus scientific arguments around anthropogenic climate change

A. Perturbed Carbon Cycle (2 weeks)

  a. Carbon fluxes and reservoirs (short-term)
  b. Emissions of CO_2 due to land use change & fossil fuels
  c. Fate of anthropogenic CO_2

B. Climate Models (3 weeks)

  a. What are they + why do we use them?
  b. Construct a simple climate model in excel and calculate warming. ($c_H*dT/dt = -\lambda T+F$)
  c. Examine possible changes using arctic ice and temperature sliders, animated climate model results
  d. Explore results from climate models and learn how to interpret them

C. Culminating Project (4 weeks)

- Students research and write a paper on their topic of interest
  - Examine how scientific uncertainty, methods, results and interpretations have developed over time
  - Identify current consensus view, and any areas of open discussion
  - Identify feedbacks that are related to the topic

- Possible shadowing of scientists or classroom visit
- Class presentation + construction of consensus document

Unit Five: Climate Impacts (6 weeks) Reading from Kump: Ch. 16

Addresses

I. Wet Wetter and Dry Dryer
II. Ocean Acidification
III. Sustainability and what do we do about it?

Impacts Question

- Question: What are the potential future impacts of climate change?
- Project: Students communicate what they've learned about their topic from Unit #4 and the potential societal/environmental impacts via a poster, PSA, website, etc.

A. Leverages existing climate impacts curricula

a. Facing the Future
b. Cool Schools Challenge