



A FUZZY FAIRY TALE

A STORY OF EXPONENTIAL GROWTH

OVERVIEW

Dr. Al Bartlett's celebrated one-hour lecture, "Arithmetic, Population and Energy: Sustainability 101", begins with the statement, "The greatest shortcoming of the human race is our inability to understand the exponential function."

This resource is focused on addressing that shortcoming as it relates to the environment. When used in conjunction with this [video](#) and [worksheet](#), this resource explains the concept of exponential growth in terms of real world environmental impacts.

TOPICS

Math, science, exponential growth, environmental pollution, consumerism, overfishing, deforestation, climate change

AUDIENCE AND SETTING

Middle school students to adult learners. This activity may be completed over the course of two-three class periods or as a take-home assignment. Possible settings include math and science classrooms.

DURATION

One to two 45-minute class periods to watch the video and complete lesson and worksheet focused on exponential growth.

OBJECTIVES

- Identify real world examples of exponential growth
- Identify negative environmental impacts caused by exponential growth and discuss real world solutions to these issues
- Utilize mathematical equations to explore real world exponential growth scenarios
- Use, interpret and explore data sets

GUIDING QUESTIONS

- How can exponential growth negatively affect environmental systems?

KEY TERMS

Carrying capacity the maximum population size of a biological species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Exponential growth increase in population proportional to the number or size of the population.

Limiting resources factors present in an environment that control a process, particularly growth, abundance or distribution of a population of organisms in an ecosystem; the availability of food, water, nutrients, shelter and predation pressure are examples of limiting factors.

J-curve a curve on a graph that records the situation in which, in an environment, the population density of an organism increases rapidly in an exponential (constant) form.

KEY CONCEPTS

- Exponential growth increases by a constant proportion.
- Doubling a small number over and over quickly becomes doubling larger numbers.

- A population cannot grow exponentially forever. It will eventually exceed its carrying capacity.
- Exponential growth can negatively affect humans and the environment.

FLORIDA STANDARDS

SC.912.N.4.1

Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.

As tomorrow's citizens, students should be able to identify issues about which society could provide input, formulate scientifically investigable questions about those issues, construct investigations of their questions, collect and evaluate data from their investigations, and develop scientific recommendations based upon their findings.

SC.912.N.4.1

Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.

SC.912.N.4.2

Weigh the merits of alternative strategies for solving a specific societal problem by comparing a number of different costs and benefits, such as human, economic, and environmental.

SC.912.L.17.1

Discuss the characteristics of populations, such as number of individuals, age structure, density, and pattern of distribution.

SC.912.L.17.5

Analyze how population size is determined by births, deaths, immigration, emigration, and limiting factors (biotic and abiotic) that determine carrying capacity.

SC.912.L.17.11

Evaluate the costs and benefits of renewable and nonrenewable resources, such as water, energy, fossil fuels, wildlife, and forests.

SC.912.L.17.16

Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

[SC.912.L.17.17](#)

Assess the effectiveness of innovative methods of protecting the environment.

[SC.912.L.17.18](#)

Describe how human population size and resource use relate to environmental quality.

[SC.912.L.17.19](#)

Describe how different natural resources are produced and how their rates of use and renewal limit availability.

EXTENSIONS

[Exponential Growth of Phytoplankton in Culture](#)

[Which Function?](#)

This activity has students distinguish between data that can be modeled in linear or exponential forms. Show how these models are different in data, algebraic, and graphical forms.

[Khan Academy – The J-curve Hypothesis](#)

[Khan Academy - Human Population Growth](#)

ADDITIONAL RESOURCES

[Exponential Growth Introduced](#)

[Introduction to Exponential Growth Tutorial](#)

This lesson will introduce the equation for exponential growth $[y=a(1+r)^t]$.

[What is Exponential Growth?](#)

[What is Doubling Time and How is it Calculated?](#)

[Using Population Growth to Explore Exponential Growth and Doubling Time](#)

[World Population Video](#)

Bury yourself in bears

The story of stuff <https://www.youtube.com/watch?v=9GorqroigqM> 21:24

Treat the Earth like you just don't care

Carbon Footprint <https://www.youtube.com/watch?v=hQ31puK7MBM> 0:30

Eat all the fish in the sea

Ending Overfishing <https://www.youtube.com/watch?v=F6nwZUkBeas> 4:20

Fill the waters with your pee

Septics 101 <https://www.youtube.com/watch?v=udBaGyzJyU8> 19:02

Chop down all the planet's trees

Follow the frog <https://www.youtube.com/watch?v=3ilkOi3srLo> 3:09

Until there's nothing left to breathe

Carbon and oxygen cycles <https://www.youtube.com/watch?v=j4Ah1jercqQ>
1:28

Spill toxins in our waters

We all live downstream <https://www.youtube.com/watch?v=6iaYfetmXbA>
0:31

Cousteau Tests for Toxins in Orcas and Man

<https://www.youtube.com/watch?v=klayrLlTh04> 5:24

Produce mutant ninja daughters

Persistent industrial chemicals in our bodies <https://vimeo.com/27744427> 7:04

Take the consumer oath

The Story of Bottled Water <http://storyofstuff.org/movies/story-of-bottled-water/>
8:05

Tis the Season to Get Trampled

<https://www.youtube.com/watch?v=iMTu4ixp9kw> 0:52

Deny exponential growth

Exponential Growth <https://www.youtube.com/watch?v=D9DvjKMMULw> 3:08

Act like we have planet's to spare

Spaceship Earth Passenger Safety Briefing

<https://www.youtube.com/watch?v=e5s1i7vTSXk> 2:09

Set fire to your hair

Global warming and wildfires: <https://www.youtube.com/watch?v=sVihBVbopjg>
2:05

Rethinking Forests: fight global warming

<https://www.youtube.com/watch?v=NrPTzw2aME0> 6:59

“The greatest shortcoming of the human race is our inability to understand the exponential function.”

“The most important video you’ll ever see”

<https://www.youtube.com/watch?v=O133ppiVnWY> 1:14:45

Note that The Rule of 70 described in Bartlett’s video is an approximation, which is most accurate for growth rates around 2% and does not work well for growth rates above 70%.

Dr. Al Bartlett’s lecture broken into ten-minute segments:

http://www.albartlett.org/presentations/arithmetric_population_energy_video1.html

ACKNOWLEDGEMENTS

Thank you to Indian River Impact 100 for funding Kilroy Academy.

Made possible with funding provided by



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