

Evolution Across the Curriculum: Thinking Evolutionarily

A Nascent and Evolving Project for
Biology Courses (9-14)

Theodosius Dobzhansky

**“Nothing in biology makes sense
except in the light of evolution.”**

American Biology Teacher, 1973

Core Evolution Group

Judy Scotchmoor, UC Museum of
Paleontology (Understanding Evolution,
Understanding Science)

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You Know the Problem

From eight Indiana and Ohio universities,
students report (Bandoli, 2008):

In my first high school biology course, the
topic of evolution was:

Not mentioned:	8-10%
Mentioned but not covered:	20-23%
Covered in less than one week:	35-39%
Covered in more than one week:	21-22%
Integrated throughout the course:	11-12%

The teacher of my first high school biology course:

- Emphasized evolution as the best way to explain the diversity of life on earth: 24-26%
- Emphasized creation as the best way to explain the diversity of life on earth: 4-6%
- Did not discuss factors responsible for the diversity of life on Earth 25-30%

Which comes closest to your personal preference among explanations for the diversity of life on Earth?

All organisms were specially created	11-18%
Result of ongoing evolutionary processes guided by a creator	42-56%
Result of ongoing evolutionary processes with no guidance	24-30%
Result of ongoing evolutionary processes augmented by supernatural intelligent intervention	9-10%

- Textbooks are written and biology classes often taught stating that evolution is a theme used throughout, however, with rare exception....evolution is taught as a subject (such as photosynthesis or animal behavior) and does not inform the entire course.

In biology classes.....

We do a great job of telling

what it is

what it does

**We don't do a very good job of
helping students understand**

how did it get this way? (evolution)

**how do we know? (evidence and the
process of science)**

Evolution Across the Curriculum (EVAC)

**Goal: to infuse evolution throughout the
biology course (from 9th grade to college)**

**Develop and implement an
integrated set of online activities
and products to encourage thinking
evolutionarily**

**Provide professional development to
help teachers think evolutionarily**

NOT A NEW CURRICULUM

**NOT A PROJECT TO HELP TEACH
EVOLUTION**

**Teachers will simply be teaching biology
(remove angst related to teaching
evolution)**

WHAT EVAC HOPES TO DO

- **Promote a teaching philosophy and practice – thinking evolutionarily**
- **Get students and teachers to think differently about biological facts and concepts**
- **Help them recognize and appreciate evidence and the process of science and to promote critical thinking**
- **One way to be proactive in the evolution/creationism battle (students can't opt out of evolution)**
- **Promote a way to make sense of biology in the light of evolution**

Thinking evolutionarily

There is an every day component—how does evolution apply to our lives?

Why do we need a new flu shot each year?

Why is the federal government spending billions to prepare for avian flu?

Why are backaches so common?

Why do I need to take all my antibiotic medicine when I feel better already?

Why doesn't the pesticide work as well as before?

What's wrong with using anti-bacterial soap?

**There is a biology course component
(A template has been developed for
writers to develop examples)**

Subject: (for every fact or concept)

What do we know about its evolution?

What evolutionary forces affect it?

How do we know?

Evidence-based learning

**Images of soil layers (to indicate time of
event) and phylogenetic trees (to indicate
relatedness)**



**PENNSYLVANIAN
STRATA**

320–286 mya

**MISSISSIPPIAN
STRATA**

360–320 mya

**DEVONIAN
STRATA**

406–360 mya

**CAMBRIAN
STRATA**

570–505 mya

EXAMPLE

Subject: Prokaryotes vs. eukaryotes

Fact: eukaryotic cells have organelles such as mitochondria and chloroplasts

Question: how did eukaryotes evolve?

Evolution: chloroplasts and mitochondria evolved from once free-living microorganisms resembling present day cyanobacteria and bacteria (endosymbiosis). These organisms were "swallowed up" by another cell, but were not destroyed.

Evidence (building a case):

- 1) both chloroplasts and mitochondria have double membranes, the outer is similar to that of bacteria**
- 2) both contain their own DNA (circular)**
- 3) both contain ribosomes that resemble those found in bacteria and not those in eukaryotes (sensitive to tetracycline but not cyclohexamide)**
- 4) chloroplast DNA can be transcribed by RNA polymerase from E. coli**

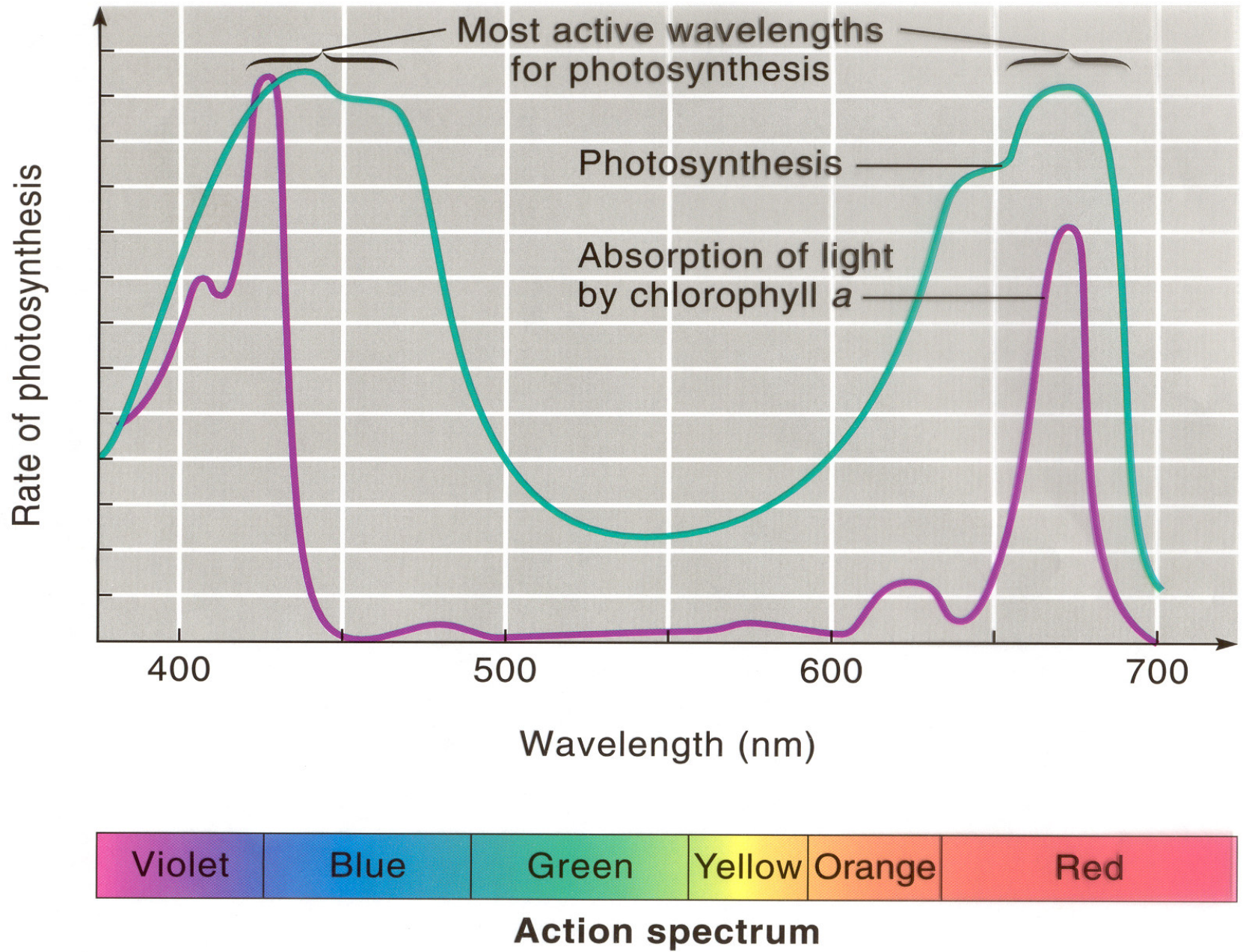
Example

Subject: Photosynthesis

Fact: Plants are green

Question: If light is necessary for photosynthesis, why aren't plants black?

Evolution: Ancestors of plants evolved at the same time as the first photosynthetic organisms, which were photosynthetic bacteria. Other early photosynthetic organisms used green light—so green light was not available to plant ancestors. Chlorophyll, the main photosynthetic pigment of plants absorbs other colors.



51 Chlorophyll a absorption spectrum
Figure 10.4

Evidence (building a case):

- 1) In stromatolites (ancient fossils), we find photosynthetic bacteria, including those similar to the purple bacterium, *Halobacterium halobium*.**
- 3) Bacteriorhodopsin is a purple, photosynthetic pigment in *Halobacterium*.**
- 4) Bacteriorhodopsin absorbs broadly in the middle of the visible spectrum (absorbs green light). So, green light was not available to chlorophyll—there was competition for different colors of light.**

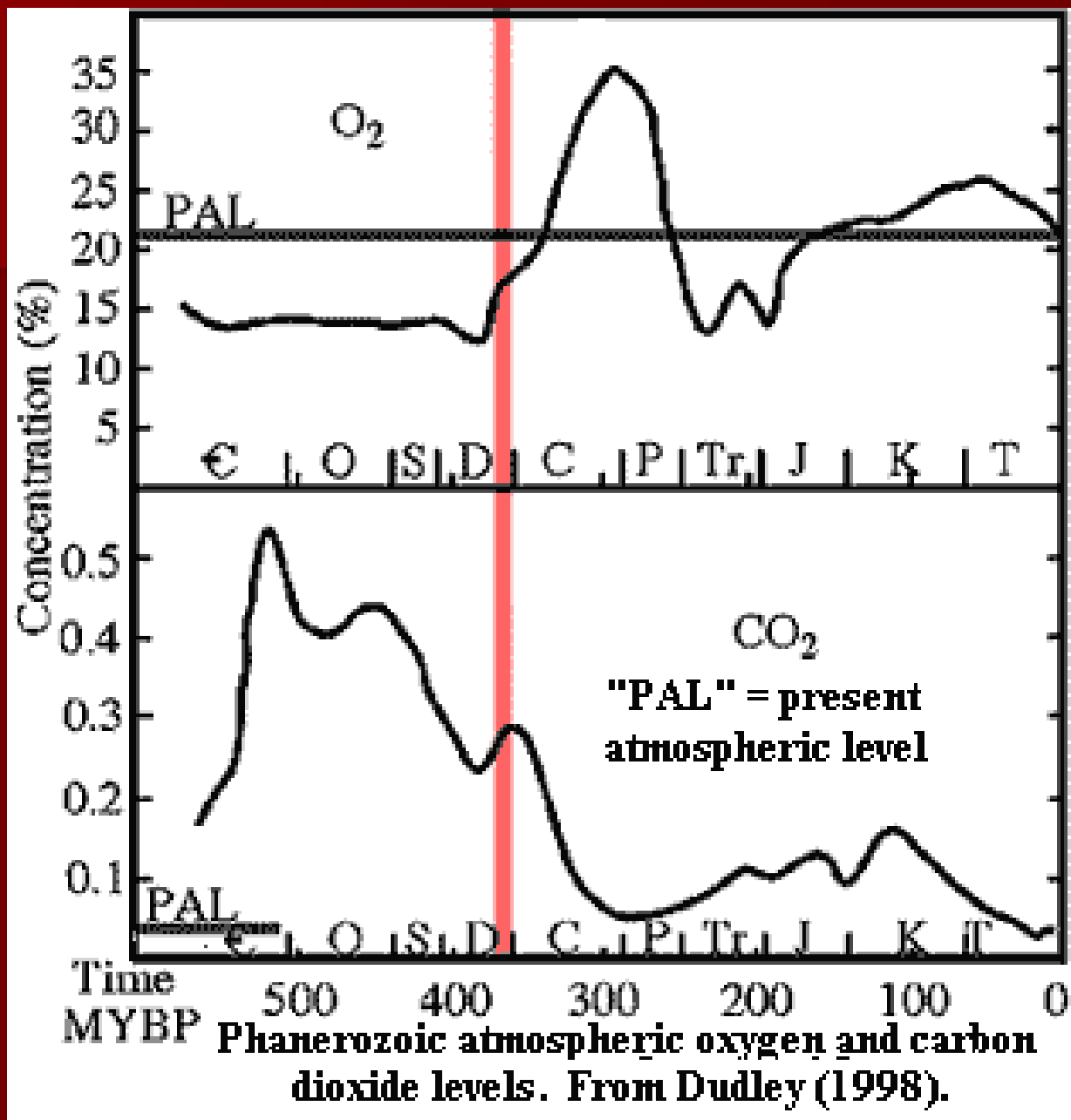
Example

Subject: Insect physiology, aerobic respiration

Fact: Dragonflies had 3-foot wingspreads about 300 million years ago

Question: How could these ancient organisms exist if they had passive intake of oxygen such as modern-day dragonflies do?

Evidence (building a case): There had to be a higher level of oxygen in the atmosphere, which allowed for evolution of larger organisms. A new method of calculating oxygen in the Earth's atmosphere suggests that an increase more than 300 million years ago was caused by the rise and spread of trees and other vascular land plants.



Project Plan

- **Holding three meetings at the NESCent headquarters in Durham**
- **Core group, local writers (high school teachers, college faculty, NESCent post-docs)**
- **We are first developing examples of how evolution impacts all the biological content**
- **Seeking funds to pilot test project**

We'll collect examples about:

- **major events in the evolutionary history of biology, including: (eukaryotes, vascular tissues, backbones, land plants, photosynthesis, multicellularity)**
- **how evolution builds on existing structures, pathways, etc. (i.e., evolution doesn't start from scratch to build an eye, a flagellum, or a complex biological pathway)**
- **touchstone examples (Goldstein, 2008)—sex, exemplary places, strange creatures**
- **every biological fact and concept!**

How you can help

- **We need examples**
- **We seek volunteers to try teaching in this manner**
- **We expect you will have suggestions**
- **We welcome collaborators**