• eukaryotes
• properties of eukaryotic cells
• endosymbiont theory of origins
• protists: a paraphyletic “junk drawer”
• survey of protist diversity
• cellular slime molds
• genetic conflict & cooperation
• FYI - a News & Views example

An added dimension


This high-resolution, three-dimensional image of a eukaryotic cell ... shows the nucleus (coloured brown) and vacuoles and vesicles (gold). Also seen are microtubules (green), which form the cell’s ‘cytoskeleton’, and mitochondria (blue) ... strung along the microtubule bundles.

The Eukaryota -along with the Archaea and Eubacteria - make up the three major branches [domains] of living organisms (viruses excepted).

Eukaryotes are usually distinguished from other forms of life by the presence of .................. {and elaborate interior (‘endo’) membranes: the nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes, various kinds of vacuoles}

The membrane-bound nuclei contain genetic information which is organized into discrete chromosomes

The word ‘eukaryote’ means ‘true nuclei’.

The cytoskeleton is comprised of a rich array of proteins. The major ones are {which forms microtubules: flagella, mitosis, melosis etc.) and forming microfilaments: cytoplasmic streaming, muscle, division etc.) and a myriad of interacting proteins [filaments] which effect movement or create the skeletal architecture of cells.

Raven et al. Table 3.2 Eukaryotic Cell Structures and Their Functions

<table>
<thead>
<tr>
<th>Structure</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell wall</td>
<td>Outer layer of nuclear or chloroplast</td>
<td>Protection, support</td>
</tr>
<tr>
<td>Cytoskeleton</td>
<td>Network of protein filaments</td>
<td>Structural support, cell movement</td>
</tr>
<tr>
<td>Flagella (cilia)</td>
<td>Cellular extensions with 9 + 2 arrangement of pairs of microtubules</td>
<td>Hair-like or moving filaments on surfaces</td>
</tr>
<tr>
<td>Plasma membrane</td>
<td>Lipid bilayer with embedded proteins</td>
<td>Regulates what passes in and out of cell, cell-to-cell interactions</td>
</tr>
<tr>
<td>Endoplasmic reticulum (ER)</td>
<td>Network of internal membranes</td>
<td>Forms compartments and vesicles, participates in protein and lipid synthesis</td>
</tr>
<tr>
<td>Nucleus</td>
<td>Structure (usually spherical) that contains chromosomes and is surrounded by double membranes</td>
<td>Control center of cell, directs protein synthesis and cell reproduction</td>
</tr>
<tr>
<td>Golgi apparatus</td>
<td>Stacks of flattened vesicles</td>
<td>Packages proteins for export from cell, forms secretory vesicles</td>
</tr>
<tr>
<td>Lysosomes</td>
<td>Vesicles formed from Golgi apparatus that contain hydrolytic digestive enzymes</td>
<td>Digest waste and organelles and cell debris, play role in cell death</td>
</tr>
<tr>
<td>Mitochondria</td>
<td>Vesicles that are formed from incorporation of lipids and proteins and that contain oxidative and other enzymes</td>
<td>Bacteria-like elements with double membranes “Power plants” of the cell, sites of oxidative metabolism</td>
</tr>
<tr>
<td>Chloroplasts</td>
<td>Reaction sites with membranes containing chlorophyll, a photosynthetic pigment</td>
<td>Sites of photosynthesis</td>
</tr>
<tr>
<td>Chromosomes</td>
<td>Long threads of DNA that form a complex with proteins</td>
<td>Contains hereditary information</td>
</tr>
<tr>
<td>Nucleus</td>
<td>Site of genes for RNA synthesis</td>
<td>Assembles chromosomes</td>
</tr>
<tr>
<td>Ribosomes</td>
<td>Small, complex assemblies of protein and RNA, when bound to endoplasmic reticulum</td>
<td>Sites of protein synthesis</td>
</tr>
</tbody>
</table>
Tumor cells multiply faster than normal cells; they are more susceptible to antimitotic plant alkaloid drugs (the plants use these “spindle poisons” as insecticides). Taxol (from yew) binds up tubulin; blocks the formation of mitotic spindles. Vinblastine (from periwinkle) causes the disassembly of formed microtubules and causes the aggregation of crystalline tubulin.

The cytoplasm of eukaryotic cells is crisscrossed by a network of protein fibers called the cytoskeleton.

3. Intermediate filaments are fibrous structural proteins, ex; keratin

2. Microtubules are hollow tubes of stiffen cell, flagella, mitotic spindles - sliding mediated by enzyme dynein

1. Actin filaments are responsible for cellular movements (muscle), “pinching” during division & formation of cellular extensions. - sliding mediated by enzyme myosin

Mitochondria & plastids replicate by a process ~
Each organelle contains a single, circular DNA molecule that, like the chromosomes of bacteria, is not associated with histones or other proteins. In terms of size, nucleotide sequence, and sensitivity to certain antibiotics, the ribosomes of mitochondria & plastids are more similar to prokaryotic ribosomes than they are to eukaryotic ribosomes.

Comparisons of rRNA from mitochondria, plastids, & various prokaryotes indicate that alpha proteobacteria are the closest relatives of mitochondria, & cyanobacteria are the closest relatives of plastids.

Over time, some of the genes originally present in mitochondria and plastids were transferred to the host cell nucleus.

The protists are the ‘junk drawer’ of eukaryotes that traditionally were not considered to be animals, fungi or plants. Advances in systematics have caused the kingdom Protista to crumble, the former kingdom is paraphyletic: some protists are more closely related to plants, fungi, or animals than to other protists. {& plants are a problem: sister clade to “green algae” – but not included in “protists”}

As a result, the kingdom Protista has been abandoned ...

Most biologists still use the term protist informally, as a convenient way to refer to eukaryotes that are neither plants, animals, nor fungi.

There are estimated to be about 200,000 named species of protists.
Six lineages are well supported w/ data (above) but many other protists are not well classified.
Additional secondary endosymbioses within the Eukaryotes

Biologists postulate that ... On several occasions during eukaryotic evolution, (eukaryotic) red algae and green algae underwent secondary endosymbiosis: They were ingested in the food vacuole of a heterotrophic eukaryote and became endosymbionts themselves.

This process likely occurred relatively recently in evolutionary time because the engulfed alga still carries out photosynthesis with its plastids and contains a tiny, vestigial nucleus of its own.

Euglenozoa

1. The Euglenoids (such as Euglena) ~1/3 of 40 genera have chloroplasts and are fully autotrophic – at least in light. No sexual reproduction is known to occur in this group!

2. The kinetoplastids (euglenozoa) with a single large mitochondrial associated the kinetoplast, that houses extranuclear DNA. Trypanosoma causes a human disease that is spread by the bite of the tsetse fly

African Trypanosomiasis (African Sleeping Sickness)

Trypanosomiasis is caused by the parasite Trypanosoma brucei, ... transmitted by the bite of the tsetse fly ... confined to tropical Africa ... According to WHO, 25,000-45,000 cases of trypanosomiasis are reported annually; however, the actual prevalence of cases is estimated to be 300,000 to 500,000.

Trypanosomes evade immune detection with a “bait–and–switch” defense. The surface of a trypanosome is coated with millions of copies of a single protein. However, before the host's immune system can mount an attack, new generations of the parasite switch to another surface protein. (antigenic shift) ~ 1/3 of Trypanosoma's genome is dedicated to these surface proteins. Vaccination is impossible due to antigenic variation of the parasites. In untreated patients ... progressive neurologic dysfunction and death.

Vaccination is impossible due to antigenic variation of the parasites. In untreated patients ... progressive neurologic dysfunction and death.

Trypanosomosis, is arguably the main constraint to livestock production on the continent, preventing full use of the land to feed the rapidly increasing human population. (by replacing wildlife w/ cattle)

African Trypanosomiasis

Trypanosoma brucei

Chronic infections result in various neurological disorders, including dementia, and damage to the heart muscle. Left untreated, it is often fatal.
**Alveolata**

Alveolata have small membrane-bounded cavities (alveoli) under their cell surfaces. The function of the alveoli is unknown; includes:

- **the Ciliates - Paramecium** - macronucleus (approx 50n) controls ‘everyday functions’ & micronuclei - swapped in sexual conjugation

- **the Apicomplexans**: spore-forming parasites

- **the Dinoflagellates**: phytoplankton - Red Tides

**Pfiesteria piscicida** ('the Cell from Hell!')

Pfiesteria piscicida is a toxic dinoflagellate that has been associated with fish lesions and fish kills in coastal waters from Delaware to North Carolina.

- At that point, *Pfiesteria* cells shift forms and begin emitting a powerful toxin that stuns the fish...
- Other toxins are believed to break down fish skin tissue, ...
- As fish are incapacitated, the *Pfiesteria* cells feed on their tissues

**Stramenopila**

Includes brown algae, diatoms & water molds. Many of the ‘seaweeds’ are:

- brown algae (ex: kelp), w/ alternation of generations ~like plants – later.
- Diatoms are photosynthetic plankton w/ glasslike silica walls {used as polishing compounds}
- the Water Molds are parasites and saprobes; not fungi: the cell walls are cellulose, not chitin.
- Potato Diseases
- Rhodophyta are red algae; extract ‘carrageenan’ makes ice cream smooth!

**Rhodophyta**

Rhodophyta are red algae; extract ‘carrageenan’ makes ice cream smooth!

**Algal Phylogeny and the Origin of Land Plants**


The [chlorophytes] that contains both protistan & higher taxa ...

http://www.epa.gov/owow/estuaries/pfiesteria/fact.html

Pfiesteria piscicida (fee-STEER-ee-uh pis-kuh-SEED-uh) is a toxic dinoflagellate that has been associated with fish lesions and fish kills in coastal waters from Delaware to North Carolina.

- Although many dinoflagellates are microscopic, free-swimming, single-celled organisms, usually classified as a type of alga.
- Pfiesteria, are more animal-like and acquire some or all of their energy by eating other organisms.

**Pfiesteria piscicida** is now known to have a highly complex life-cycle with 24 reported forms, a few of which can produce toxins.

- *Pfiesteria* only becomes toxic in the presence of fish, triggered by their secretions or excrement in the water.
- At that point, *Pfiesteria* cells shift forms and begin emitting a powerful toxin that stuns the fish...
- Other toxins are believed to break down fish skin tissue, ...
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**Algal Phylogeny and the Origin of Land Plants**


The [chlorophytes] that contains both protistan & higher taxa ...
**Slime molds (not a phylogenetic clade)**

http://www.ucmp.berkeley.edu/protista/slimemolds.html

The **cellular slime molds**, spend most of their lives as separate single-celled amoeboid protists, but *when food depleted* the release of a chemical signal (cAMP) causes the individual cells to aggregate… they provide a simple system for understanding **how cells interact to generate a multicellular organism.**

**Dictyostelida (Cellular Slime Molds)** – haploid, Fig 28.27

Raising questions about what it means to be an individual organism. Serves as a model for the evolution of:

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**Letters to Nature**

**Altruism and social cheating in the social amoeba Dictyostelium discoideum**


The social amoeba, *Dictyostelium discoideum*,... its multicellular fruiting stage is really a society. Most of the time, *D. discoideum* lives as haploid, free-living, amoeboid cells that divide asexually. When starved, $10^4-10^5$ of these cells aggregate into a slug. The anterior 20% of the slug altruistically differentiates into a non-viable stalk, supporting the remaining cells, most of which become viable spores.

If aggregating cells come from multiple clones, there should be selection for clones to contributing less than their proportional share to the sterile stalk. Here we use microsatellite markers to show that different clones collected from a field population readily mix to form chimerae. **Half of the chimaeric mixtures show a clear cheater and victim.** Unlike the clonal and highly cooperative development of most multicellular organisms, the development of *D. discoideum* is partly competitive, with **conflicts of interests** among cells. These conflicts... make it highly attractive as a model system for social evolution.

**Kin preference in a social microbe**


... *Dictyostelium purpureum* preferentially associates with kin ...

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**Science**

**Bickering Genes Shape Evolution**

Elizabeth Pennisi


Not all genes follow the rules of inheritance; now researchers are discovering how organisms adapt to the troublemakers.

Reproduction is supposed to be an equal opportunity event.

But in humans, flies, mice, and perhaps many other organisms, guerrilla warfare within the genome sometimes pits one element against another.

Genes usually work together. Their survival depends on their collective ability to make an individual run fast, eat well, reproduce efficiently, and ward off infections. Still, as biologists are increasingly coming to realize, not all versions--called alleles-- of each gene are alike.

Some appear to look out for themselves. Somehow, they are more adept at passing copies of themselves on, sometimes even crowding other alleles out. *(meiotic drive)* ... deep inside every individual there’s a lot of conflict going on.

**Evidence for extensive transmission distortion in the human genome.**


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**A digression on your News & Views assignment**

**Pfiesteria shumwayae** kills fish by micropredation not exotoxin secretion **A ‘target article’**

Wolfgang H. Vogelberg, Vincent J. Lovich, Jeffrey D. Shields, Kimberly S. Reese, Patricia L. Madison, Leonard W. Haas & Calvin C. Walker

*Pfiesteria piscicida* and *P. shumwayae* reportedly secrete potent exotoxins thought to cause fish lesion events, acute fish kills and human disease. *Pfiesteria* toxins have never been isolated or characterized.

We investigated mechanisms by which *P. shumwayae* kills fish...

Here we show that larval fish bioassays conducted in tissue culture plates fitted with polycarbonate membrane inserts exhibited mortality (100%) only in treatments where fish and dinospores were in physical contact.

No mortalities occurred in treatments where the membrane prevented contact between dinospores and fish. ... Videomicrography and electron microscopy show dinospores swarming toward and attaching to skin, actively feeding, and rapidly denuding fish of epidermis.

We show here that our cultures of actively fish-killing *P. shumwayae* do not secrete potent exotoxins; rather, fish mortality results from micropredatory feeding. ...
news and views
Nature 418, 927 - 930 (2002); doi:10.1038/418927a

Marine biology: Unveiling an ocean phantom
VERA L TRAINOR

Certain episodes of mass fish mortality in coastal waters off the eastern United States have been ascribed to a planktonic organism called *Pfiesteria*. There are now fresh clues to how these fish are killed.

In James Powilk’s novel *Sea Change*, a colony of mutant cells called *Pfiesteria* grows into a carpet-like monster stretching over several square miles of the Strait of Juan de Fuca, a body of water separating the west coast of the United States and Canada. Its slow movement south threatens the residents of Seattle with a nightmarish fate — death following ingestion or ingestion of a toxin produced by the microbes.

The good news is that the Sea Change story is fiction; the bad news is that *Pfiesteria* is fact. But what is the truth about this ‘phantom of the ocean’? It is thought that *Pfiesteria*, which belongs to a group of planktonic organisms called dinoflagellates, releases a toxin that ultimately kills fish. But using simple methods, Vogelbein and his colleagues (page 967 of this issue) conclude that the toxin is not released into the environment and that the organism kills by direct methods.

If they are not killed by a toxin, how do fish exposed to *Pfiesteria* die? It has been known for many years that *Pfiesteria* cells extend a suction-cup-like appendage called a peduncle to digest fish tissue. Vogelbein et al. go a step further and propose that fish die because *Pfiesteria* literally sucks the life out of them. It attaches to fish skin using the peduncle, extending finger-like protrusions called filopodia, then ingests cell matter from the fish. This parasitic feeding behaviour by *Pfiesteria* is detailed in high-magnification microscope images in Vogelbein et al., and in a video clip available in their Supplementary Information.

A digression on your News & Views assignment

What questions are left unanswered & what needs to be done next?
- more critical creativity from your own brain!

Ongoing controversy over *Pfiesteria*

Burkholder, J. SCIENCE 304 (5667): 46-46 APR 2 2004

News and views
Nature 418, 927 - 930 (2002); doi:10.1038/418927a

In reality, the presence of *Pfiesteria* has not been documented along the US west coast but rather along the eastern seaboard, with a range from Delaware to Alabama. It has been associated with massive fish kills, especially off North Carolina. Because of the harm that results when *Pfiesteria* multiplies to high numbers, it is categorized with other plankton known to cause harmful ‘blooms’. Many of these bloom-forming organisms produce potent toxins, so the assumption that *Pfiesteria* releases a toxin is not unfounded. Moreover, the population explosions of various single-celled plankton, including diatoms and dinoflagellates, are frequently associated with the production of nerve toxins — saxitoxin, brevetoxin, maitotoxin and the like. — that are damaging when ingested by higher organisms.

These toxins are the key for researchers wishing to unlock the secrets of harmful algal blooms. By knowing the chemical identity of the toxins, highly specific detection methods can be developed to track the location of blooms and to discover where they originate, how they spread and when they are most toxic. The impact of harmful algae on living creatures, such as seabirds, marine mammals and even humans, can be assessed by determining the levels of toxin in their tissues and body fluids. But first the toxins must be isolated from the clusters of cells that release them into the environment.

The basic story before the target article (you can get this from the TA Intro. & the text)

A nice, simple summary of what the authors did & found
- you need to craft this with your own brain!

References