Mitochondrial genomes

Assembling, correcting, annotating and submitting complex DNA sequences
Finishing up nuclear rDNA

• Finish up correcting errors, annotating, and submitting this week
• In addition to normal office hours, Kyle will help after 2pm Thursday
• I can help Wednesday morning as well
Nuclear ribosomal internal transcribed spacer (ITS) region as a universal DNA barcode marker for *Fungi*

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Why DNA barcoding works: genes with the right number of differences
organelles
Origins

- Endosymbiosis 1.5-2.5 Billion years ago
- Lost most of their genes
  - Genes / gene functions transferred to nucleus
- Genome size heavily reduced
The ENDOSYMBIOTIC THEORY

1. Infoldings in the plasma membrane of an ancestral prokaryote gave rise to endomembrane components, including a nucleus and endoplasmic reticulum.

2. In a first endosymbiotic event, the ancestral eukaryote consumed aerobic bacteria that evolved into mitochondria.

3. In a second endosymbiotic event, the early eukaryote consumed photosynthetic bacteria that evolved into chloroplasts.

Proto-eukaryote

Modern photosynthetic eukaryote

Modern heterotrophic eukaryote
Years Ago

Prokaryotes
- Bacteria
- Archaea
- Protists

Eukaryotes
- Plants
- Fungi
- Animals

- Hard bodies
- Soft bodies
- Multi-celled organisms
- Eukaryotes with organelles
- Eukaryotes (DNA in nucleus)
- Prokaryotes (no nucleus, free DNA)
- Last Universal Common Ancestor (LUCA) of all current Earth Life

Chloroplast assimilation (?)
Mitochondrion assimilation (?)

One Thousand Million Years
Three Thousand Million Years
• The origin and early evolution of eukaryotes in the light of phylogenomics
• Eugene V Koonin
• Genome Biology 2010 11:209

• Phylogenomics of eukaryote supergroups suggest a highly complex last common ancestor of eukaryotes and a key role of mitochondrial endosymbiosis in the origin of eukaryotes.

Evolution of mitochondrial genome

• free-living α-proteobacterial ancestor probably had ~1600+ protein-coding genes
• Today, far fewer – many have been lost or transferred to the nuclear genome
Mammalian mitochondria

- 37 protein-coding genes
- 22 tRNA
- 11-28kb genome size (most ~16kb), 1 circle
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The involvement of mitochondrial DNA in several human diseases.
Less complex mitochondrial genomes encode subsets of the proteins and ribosomal RNAs that are encoded by larger mitochondrial genomes. The five genes present in all known mitochondrial genomes encode ribosomal RNAs (\textit{rns} and \textit{rnl}), cytochrome \textit{b} (\textit{cob}), and two cytochrome oxidase subunits (\textit{cox1} and \textit{cox3}). (Adapted from M.W. Gray et al., \textit{Science} 283:1476–1481, 1999.)
Plant and fungal mitochondria

- 8-127+ protein-coding genes (NCBI)
- 22 tRNA
- 19,000-1,000,000+bp genome size
- Can be 1 circle, 2+ circles, or 1 linear molecule
Your final project: a compete organellar genome

1. Identify the correct sequence(s)
2. Construct a complete, assembled genome – may be done
3. Error correct (you know how!)
4. Annotate
   - Much more complicated if you have more genes
   - More challenging due to differences in gene order, gene content
5. Submit
   - Much more complicated if you have more genes
Plant and fungal mitochondria

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Your fungal mitochondria

- All ascomycete lichenized fungi
- 20kb-90kb
- Lots of variation in gene order
- Less variation in gene content
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First steps - by next Tuesday

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2. Construct a complete, assembled genome – may be done
3. Error correct (you know how!)