



D-Loop in Mitochondrion

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SVFIG
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Life Forms

- **All life forms were poorly designed.**
- **Too many compromises had to be made to deal with many different external requirements.**



Plants

- **Plants were better designed.**
- **External constraints are much less stringent.**
- **They acquire energy from sun light.**
- **They do not have to move.**



Animals

- **Animals were much more difficult to designed.**
- **They acquire energy from eating. Foods must be digested, and stored away.**
- **They have to move by burning stored nutrients for energy.**



Respiratory and Circulatory Systems

- **Oxygen is required to produce energy.**
- **Oxygen is toxic.**
- **Red cells must be sacrificed to carry oxygen to cells.**
- **Mitochondria are incorporated to oxidize nutrients for ATP.**
- **Oxygen escaping mitochondria must be neutralized by vitamin C.**



Mitochondria

- **Smallest endosymbiotic organisms required by all cells.**
- **Its DNA genome is inherited from mother, independent of nuclear genomes.**
- **Human mitochondrion has 16,569 bases.**

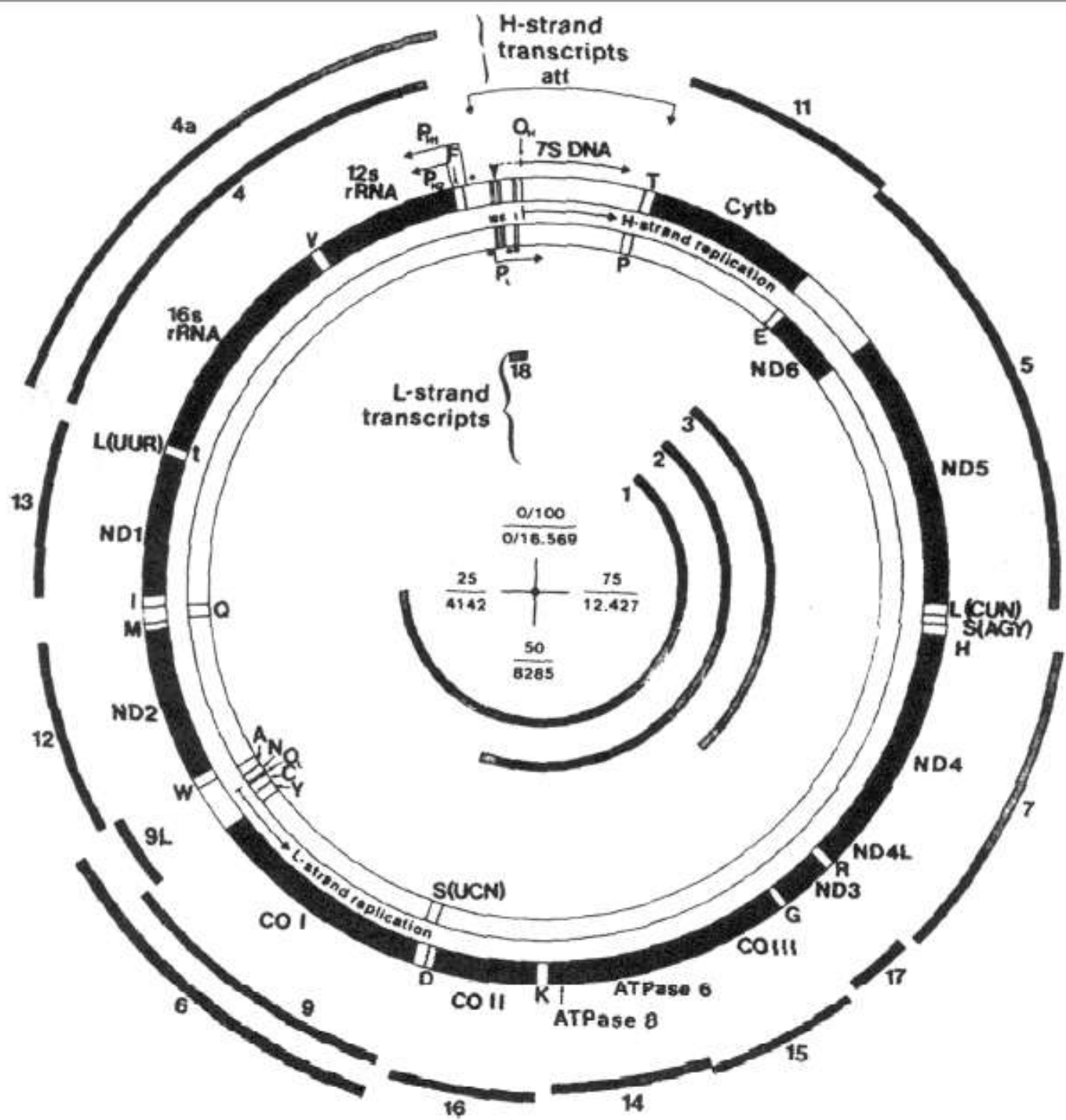
Mitochondria





Mitochondrial Genome

- It encodes 37 genes:
 - 13 for subunits of respiratory complexes I, III, IV and V
 - 22 for mitochondrial tRNA (for the 20 standard amino acids)
 - 2 extra genes for leucine and serine
 - 2 for rRNA
- One mitochondrion can contain two to ten copies of its DNA.

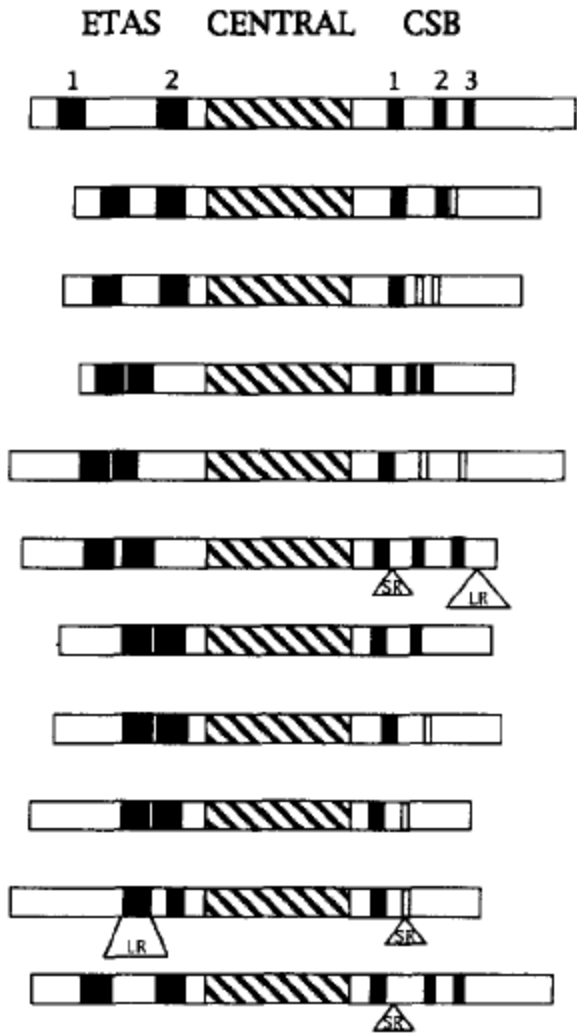




Mitochondrial D-Loop

- **Three sections (1122 bases):**
 - **Left section, 371 (16024-16394)**
 - **Central section, 309 (16395-134)**
 - **Right section, 442 (135-576)**
- **Conserved blocks**
 - **Termination Associated Sequences**
 - **Central Section**
 - **Conserved Sequence Blocks**

Conserved Blocks in D-Loop



- | | |
|--------------------------------------|--------------|
| <i>H. lar, H. sapiens</i> | PRIMATES |
| <i>P. paniscus, P. troglodytes</i> | |
| <i>G. gorilla</i> | |
| <i>P. pigmaeus</i> | |
| <i>M. musculus, R. norvegicus</i> | RODENTIA |
| <i>G. glis</i> | |
| <i>O. cuniculus</i> | LAGOMORPHA |
| <i>C. commersonii, B. mysticetus</i> | CETACEA |
| <i>K. breviceps</i> | |
| <i>B. taurus</i> | ARTIODACTYLA |
| <i>O. aries</i> | |
| <i>D. bicornis</i> | |

D-Loop Base Map (1997)

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16021	·ctg	tctttc	·atg	gggaagc	·agat	ttgggt	·acc	accaag	·tatt	gactca	·ccc	atcaaca
16081	·acc	gctatgt	·att	tctgaca	·ttac	tgccag	·ccac	catgaa	·tatt	gtacgg	·tacc	ataaat
16141	·act	tgaccac	·ctg	tagtaca	·taaa	aacca	·atcc	acatca	·aaac	cccctc	·ccc	atgctta
16201	·caag	caagta	·cag	caatcaa	·ccct	caacta	·tcac	acatca	·act	gcaactc	·caa	agccacc
16261	·cct	caccac	·tag	gatacca	·aca	aacctac	·cca	cccttaa	·cag	tacatag	·tac	ataaagc
16321	·catt	taccgt	·aca	tagcaca	·ttac	agtcaa	·atc	cccttc	·gtc	cccatgg	·atg	accccc
16381	·tcag	ataggg	·gtc	ccctgac	·cacc	atcctc	·cgt	gaaatca	·atat	cccgc	·caag	agtgct
16441	·act	ctcctcg	·ctc	cgggccc	·ata	acacttg	·ggg	gtagcta	·aag	tgaactg	·tat	ccgacat
16501	·ctg	gttctta	·ctt	cagggtc	·ata	aagccta	·aat	agcccac	·acg	ttcccct	·taa	ataagac
16561	·atc	acgatg	¶									
· · · 1	·gat	cacaggt	·ctat	caccct	·atta	accact	·cac	gggagct	·ctcc	atgcat	·ttg	gtatttt
· · · 61	·cgt	ctggggg	·gtat	gcacgc	·gat	agcattg	·cgag	acgctg	·gag	ccggagc	·acc	ctatgtc
· · 121	·gcag	tatctg	·tctt	tgattc	·ctg	cctcatc	·ctat	tattta	·tcg	cacctac	·gtt	caatatt
· · 181	·acag	gcgaac	·ata	cttacta	·aag	tgtgta	·atta	attaat	·gct	tgtagga	·cata	ataata
· · 241	·aca	attgaat	·gtc	tgcacag	·ccA	ctttcca	·cac	agacatc	·ata	acaaaa	·att	tccacca
· · 301	·aac	ccccct	·CCCC	gcttc	·tgg	ccacagc	·act	taaacac	·atct	ctgcca	·aac	ccccaaaa
· · 361	·aca	aagaacc	·cta	acaccag	·cct	aaccaga	·ttt	caaattt	·tat	cttttgg	·cgg	tatgcac
· · 421	·ttt	taacagt	·cacc	ccccca	·cta	acacatt	·att	ttcccct	·ccc	actcca	·tact	actaat
· · 481	·ctc	atcaata	·caac	ccccgc	·ccat	cctacc	·cag	cacacac	·acac	cgctgc	·taac	ccccata
· · 541	·cccc	gaacca	·acca	aacccc	·aaag	acaccc	·ccc	acagttt	·atg	tagctta	·cct	cctcaaa

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D-Loop Base Map (2017)

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16021 · ctggttctttc · atggggaagc · agatttgggt · accaccaag · tattgactca · cccatcaaca ¶

16081 · accgctatgt · atttcgtaca · ttactgccag · ccaccatgaa · tattgtacgg · taccataaat ¶

16141 · acttgaccac · ctgtagtaca · taaaaacca · atccacatca · aaaccacctc · cccatgctta ¶

16201 · caagcaagta · cagcaatcaa · ccctcaacta · tcacacatca · actgcaactc · caaagccacc ¶

16261 · cctcaccac · taggatacca · acaaacctac · ccacccttaa · cagtacatag · tacataaagc ¶

16321 · catttaccgt · acatagcaca · ttacagtcaa · atcccttctc · gtccccatgg · atgaccccc ¶

16381 · tcagataggg · gtcccttgac · caccatcctc · cgtgaaatca · atatcccgca · caagagtgct ¶

16441 · actctcctcg · ctccgggccc · ataacacttg · ggggtagcta · aagtgaactg · tatccgacat ¶

16501 · ctgggtccta · cttcagggtc · ataaagccta · aatagccac · acgttccct · taaataagac ¶

16561 · atcacgatg ¶

· · · 1 · gatcacaggt · ctatcacct · attaaccact · cacgggagct · ctccatgcat · ttggta ttt ¶

· · · 61 · cgtctggggg · gtatgcacgc · gatagcattg · cgagacgctg · gagccggagc · accctatgtc ¶

· · · 121 · gcagtatctg · tctttgattc · ctgcctcatc · ctattattta · tcgcacctac · gttcaatatt ¶

· · · 181 · acaggcgaac · atacttacta · aagtgtgtta · attaattaat · gcttgtagga · cataataata ¶

· · · 241 · acaattgaat · gtctgcacag · ccActttcca · cacagacatc · ataacaaaa · atttccacca ¶

· · · 301 · aacccccct · CCCCCgcttc · tggccacagc · acttaaacac · atctctgcca · aaccccaaaa ¶

· · · 361 · acaagaacc · ctaacaccag · cctaaccaga · tttcaaattt · tatcttttgg · cggtatgcac ¶

· · · 421 · ttttaacagt · cccccccaa · ctaacacatt · attttccct · cccactcca · tactactaat ¶

· · · 481 · ctcatcaata · caacccccgc · ccatcctacc · cagcacacac · acaccgctgc · taaccccata ¶

· · · 541 · ccccgaacca · accaaacccc · aaagacaccc · cccacagttt · atgtagctta · cctcctcaaa ¶

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Start and Stop Codons

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16021 ·ctggttctttcatggggaagcagatttgggtaccaccaagtattgactcaccatcaaca¶
16081 ·accgctatgtatttcgtacattactgccagccaccatgaatattgtacgggtaccataaat¶
16141 ·acttgaccacctgtagtacataaaaacccaatccacatcaaaaacccctccccatgctta¶
16201 ·caagcaagtacagcaatcaaccctcaactatcacacatcaactgcaactccaagccacc¶
16261 ·cctcaccactaggataccaacaaacctaccacccttaacagtacatagtacataaagc¶
16321 ·catttaccgtacatagcacattacagtcaaaatcccttctcgtccccatggatgaccccc¶
16381 ·tcagatagggtcccttgaccaccatccctcgtgaaatcaatatccgcacaagagtgtct¶
16441 ·actctctcgtcctccgggccataacacttgggggtagctaaagtgaactgtatccgacat¶
16501 ·ctgggttctacttcagggtcataaagcctaaatagcccacacgttcccttaaataagac¶
16561 ·atcacgatg¶
···1 ·gatcacagggtctatcacctattaaccactcacgggagctctccatgcatttgggtatttt¶
···61 ·cgtctggggggtatgcacgcatagcattgcaagacgctggagccggagcacctatgtc¶
···121 ·gcagtatctgtctttgattcctgcctcatcctattatttatcgcacctacgttcaatatt¶
···181 ·acaggcgaacatacttaactaaagtgtgttaattaattaatgcttgtaggacataataata¶
···241 ·acaattgaatgtctgcacagccActttccacacagacatcataacaaaaaatttccacca¶
···301 ·aacccccctCCCCgcttctggccacagcacttaaacacatcctctgccaacccccaaaa¶
···361 ·acaaagAACCTAACACCAGCCTAACAGATTCAAATTTATCTTTTGGCGGTATGCAC¶
···421 ·ttttaacagtcaccccccaactaacacattattttcccctcccactcccataactaata¶
···481 ·ctcatcaatacaacccccgccatcctaccagcacacacacacgctgctaaccata¶
···541 ·ccccgaaccaaccaaccccaaagacacccccacagtttatgtagcttacctcctcaaa¶
```

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Longest Repeated Patterns

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```
16021 · ctgttctttcatggggaagcagatttgggtaccaccaagatattgactcacccatcaaca¶
16081 · accgctatgtatttcgtacattactgccagccaccatgaatatgtacgggtaccataaat¶
16141 · acttgaccacctgtagtacataaaaacccaatccacatcaaaaccccctccccatgctta¶
16201 · caagcaagtacagcaatcaaccctcaactatcacacatcaactgcaactccaaagccacc¶
16261 · cctcaccactaggataccaacaaacctaccacccttaacagtacatagtacataaagc¶
16321 · catttaccgtacatagcacattacagtcaaatcccttctcgtccccatggatgaccccc¶
16381 · tcagataggggtcccttgaccaccatcctccgtgaaatcaatatcccgcacaagagtgct¶
16441 · actctctcgtccgggcccataacacttgggggtagctaaagtgaactgtatccgacat¶
16501 · ctggttcctacttcagggtcataaagcctaaatagcccacacggtcccttaataagac¶
16561 · atcacgatg¶
· · · 1 · gatcacaggtctatcaccctattaaccactcacgggagctctccatgcatttgggtattt¶
· · 61 · cgtctgggggggatagcacgcgatagcattgcgagacgctggagccggagcaccctatgct¶
· · 121 · gcagtatctgtctttgattcctgcctcatcctattatttatcgcacctacgttcaatatt¶
· · 181 · acaggcgaacatacttaactaaagtgtgttaattaattaatgcttgtaggacataataata¶
· · 241 · acaattgaatgtctgcacagccActttccacacagacatcatacaaaaaatttccacca¶
· · 301 · aacccccctCCCCgcttctggccaacagcacttaaacacatctctgccaaacccccaaa¶
· · 361 · acaaagaaccctaacaccagcctaaccagatttcaaattttatcttttggcgggtatgcac¶
· · 421 · ttttaacagtcaccccccaactaacacattattttccctcccactcccatactactaat¶
· · 481 · ctcatcaatacaacccccgcccattctaccagcacacacacacccgctgctaaccaccata¶
· · 541 · ccccgaaaccaaccaaaccacaaagacaccccccaagtttatgtagcttacctcctcaaa¶
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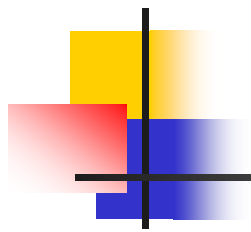
Longest Patterns

- **The longest repeated patterns in the central conserved sections are:**
 - **caccctat**
 - **tgggggta/tgggggta**
 - **gacatc**
- **What I expect are:**
 - **Call and return**
 - **Jump and conditional jump**

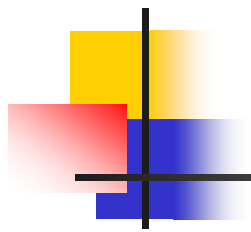


Secrets of Life

- **Central conserved section in mitochondrial D-Loop looks like a computer program.**
- **We need to look up the code, `caccctat`, `tgggggta/tgggggta` and `gacatc` in nuclear genomes to see if they are parts of genetic programs.**



Questions?



Thank You!