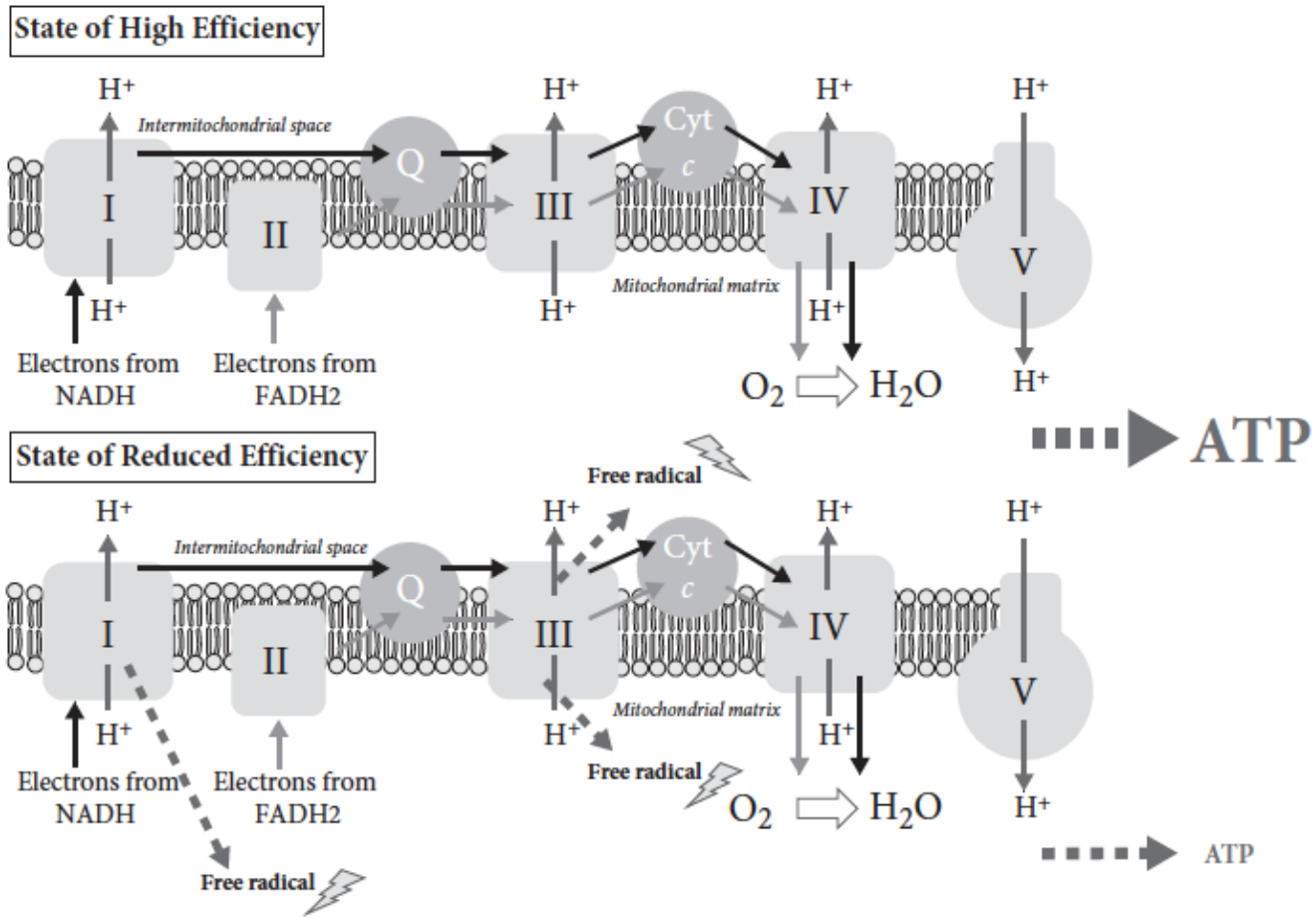
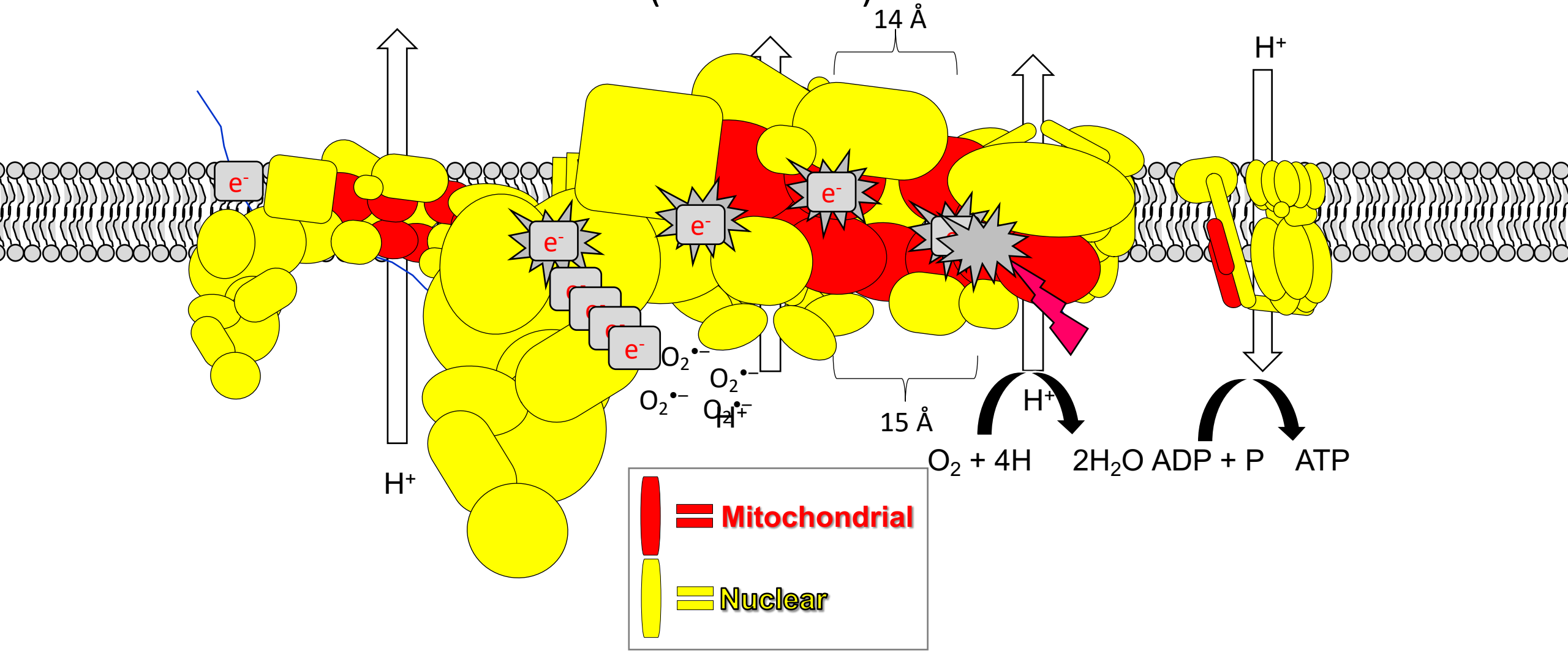
Forms and consequences of incompatibility

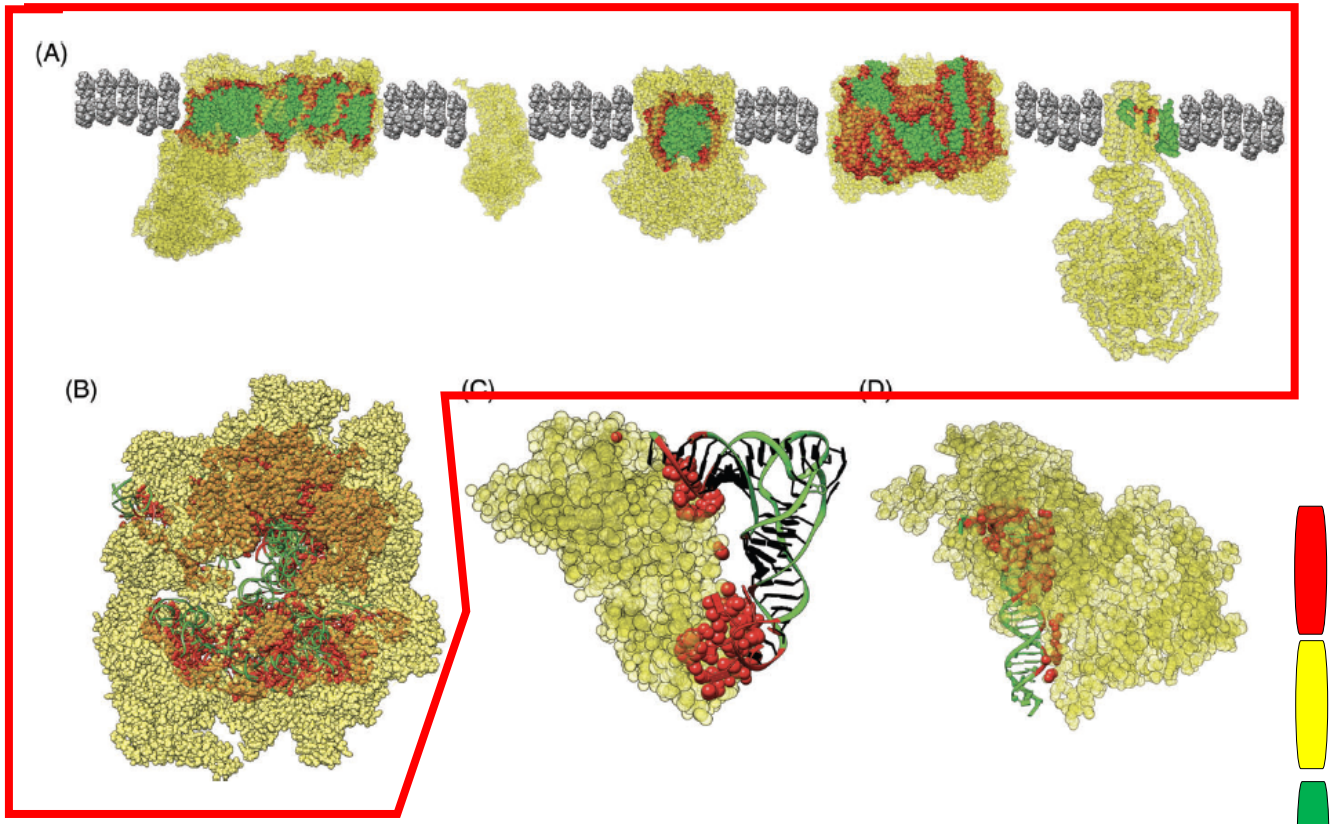
OXPHOS again



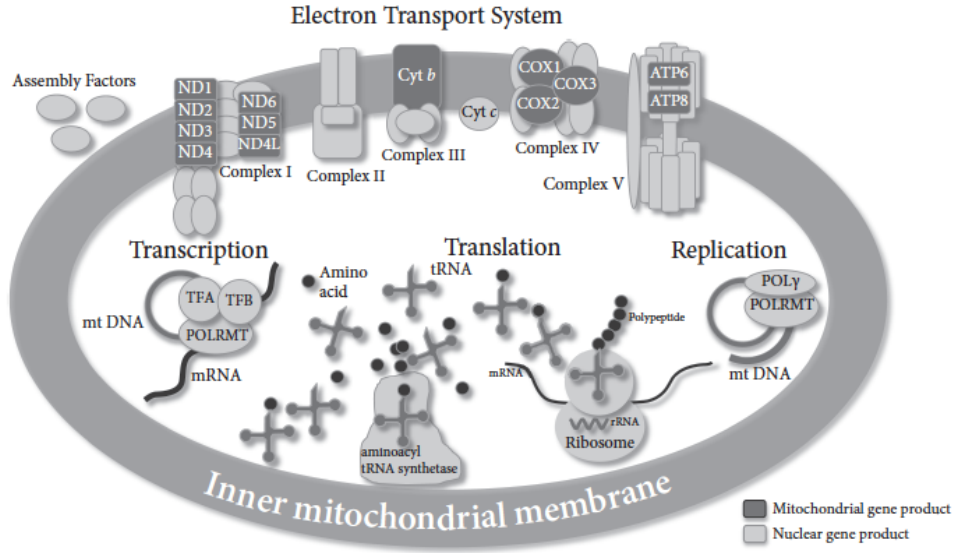
Oxidative phosphorylation (OXPHOS)

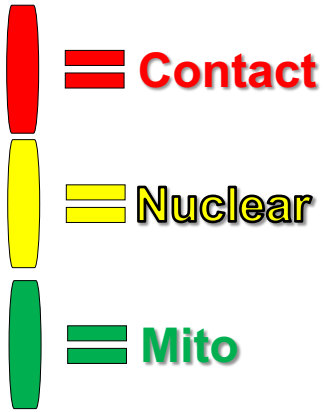


Types of mitonuclear interactions and potential for incompatibilities

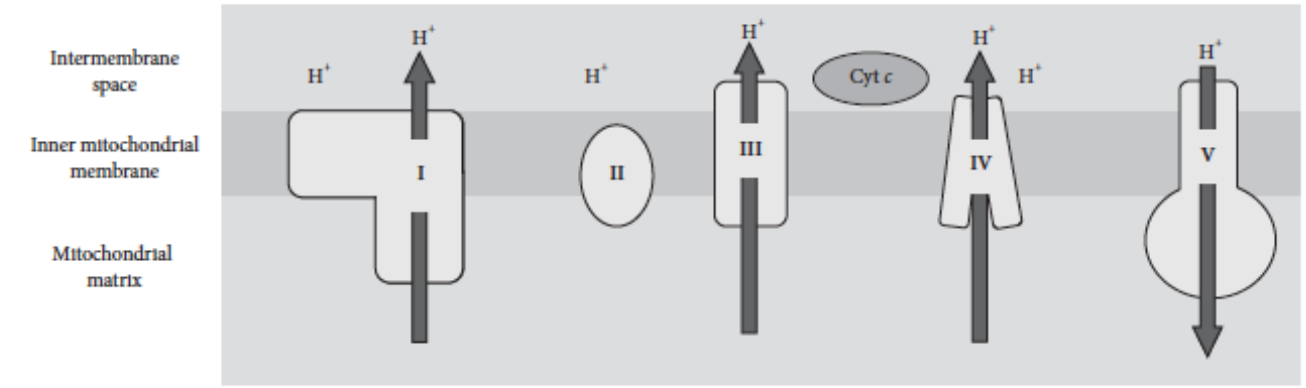


Hill et al. 2019





Protein-protein interactions

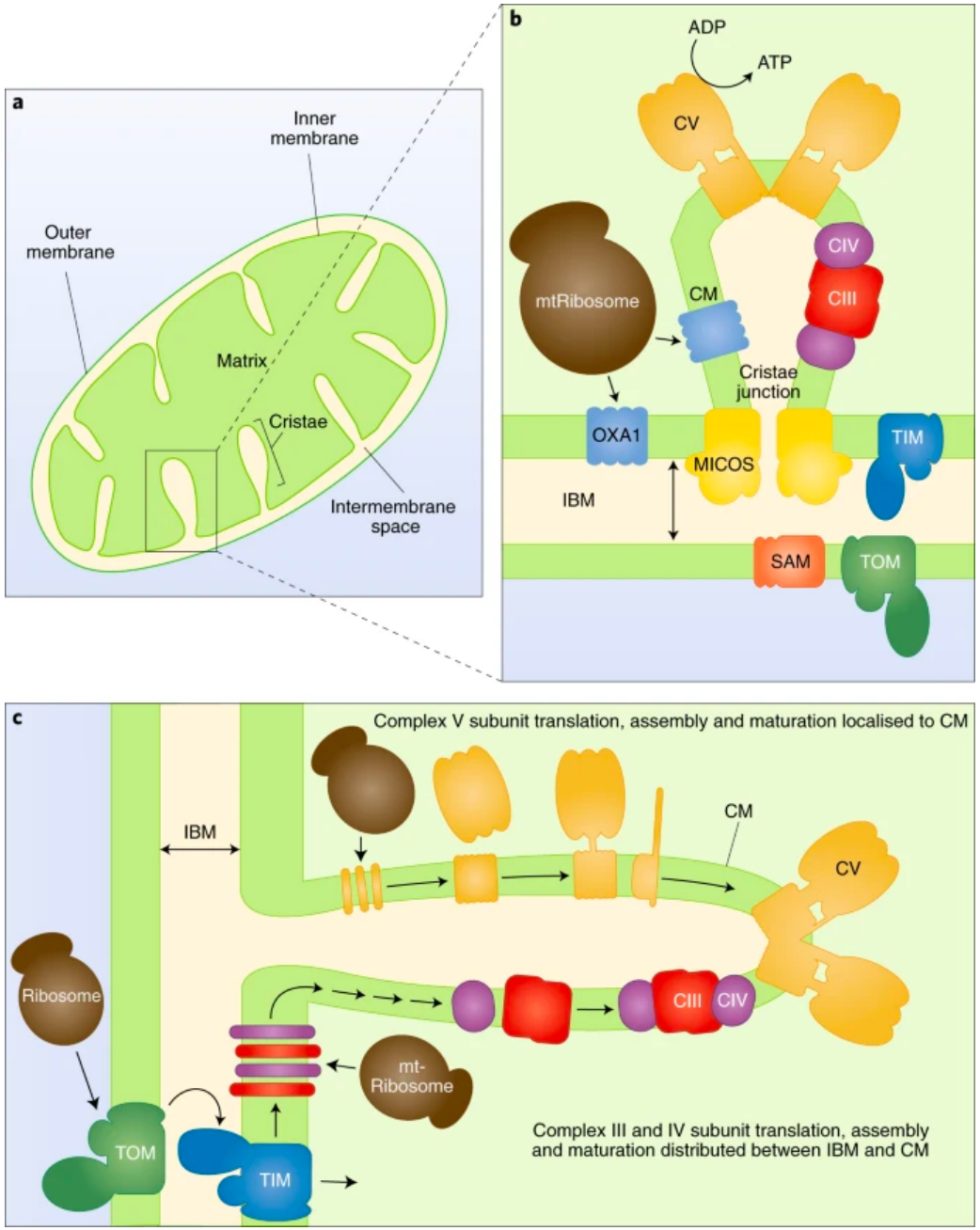


OXPHOS Component	Complex I	Complex II	Complex III	Complex IV	Complex V
mt-encoded proteins	**7**	**0**	**1**	**3**	**2**
mt DNA structural subunit genes	**ND1, ND2, ND3, ND4, ND4L, ND5, ND6**	**None**	**Cyt *b***	**COX1, COX2 COX3**	**ATP6 ATP8**
N-encoded proteins	**37**	**4**	**10**	**10**	**12**
Structural subunit genes	**NDUFS1, NDUFS2, NDUFS3, NDUFS4,** NDUFS5, **NDUFS6, NDUFS7, NDUFS8, NDUFA1, NDUFA2,** NDUFA3, NDUFA5, NDUFA6, NDUFA7, NDUFA8, **NDUFA9, NDUFA10, NDUFA11, NDUFA12, NDUFA13,** NDUFAB1, **DNUFV1, NDUFV2, DNUFV3,** DNUFB1, NDUFB2 **NDUFB3,** NDUFB4, NDUFB5, NDUFB6, NDUFB7, NDUFB8, **NDUFB9** NDUFB10, **NDUFB11,** NDUFC1, NDUFC2	**SDHA, SDBH,** SDHC **SDHD**	**UQCRB** UQCRC1 **CYC1 UQCRC2** UQCRFS1 UQCRH **UQCRQ** UQCR10 UQR11	**COX4** COX5A COX5B **COX6A COX6B** COX6C COX7A **COX7B** COX7C **COX8**	**ATP5A1,** ATP5B ATP5C1, ATP50D **ATP5E,** ATP5F1 ATP5G1, ATP5G2 ATP5G3, ATP5H5I ATP5O, ATP5J ATP5J2, ATP5L APT5L2

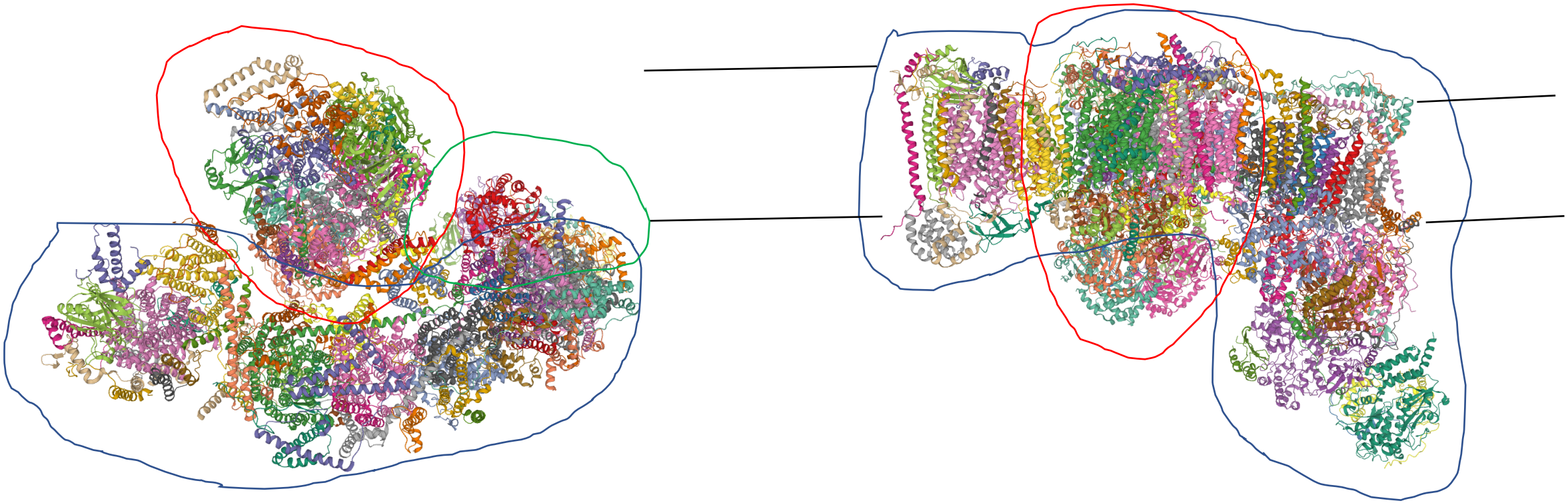
Assembly factors

Mitochondria are critical for cellular energy generation and house oxidative phosphorylation (OXPHOS) complexes, which are under dual genetic control. A study finds that transcript translation and complex assembly are partitioned, and OXPHOS complexes III, IV and V are built at spatially defined regions of the mitochondrial inner membrane.

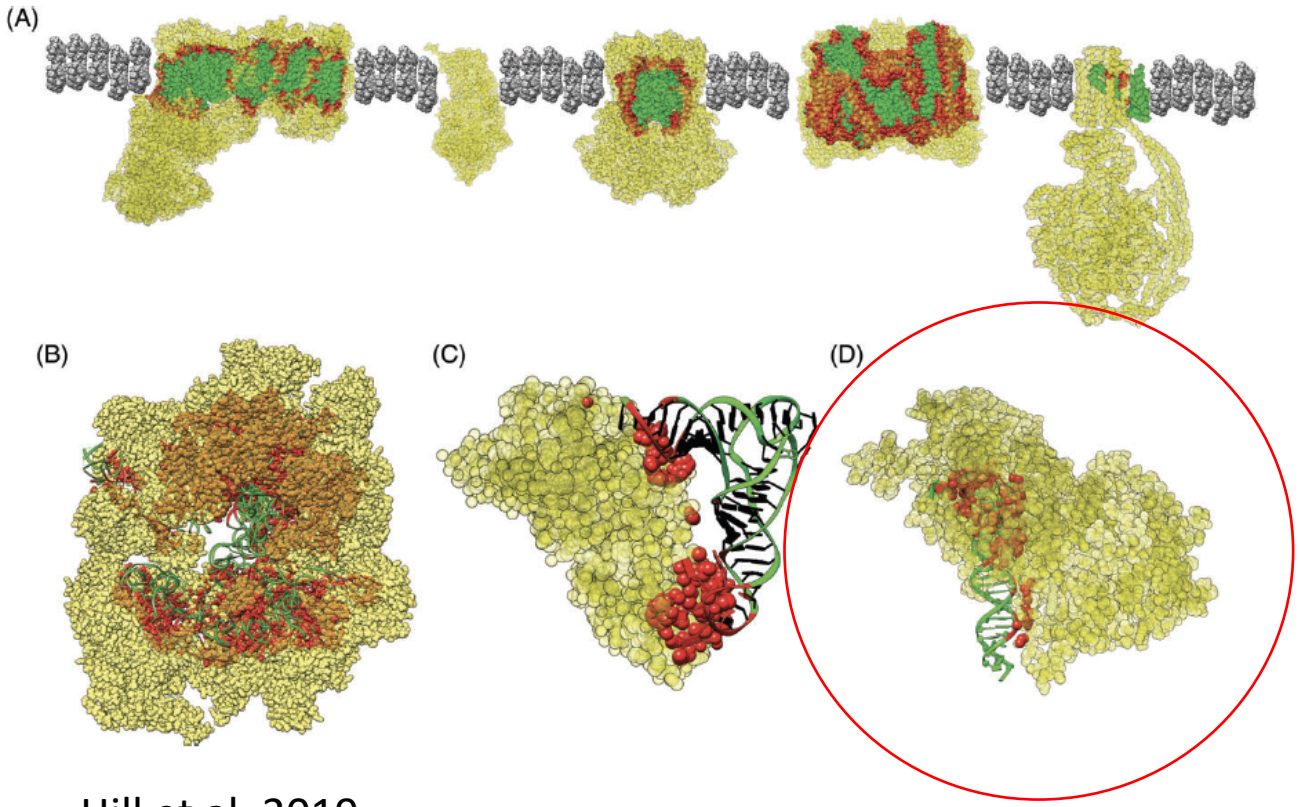
Stoldt, S. et al. *Nat. Cell Biol.*, https://doi.org/10.1038/s41556-018-0090-7 (2018).



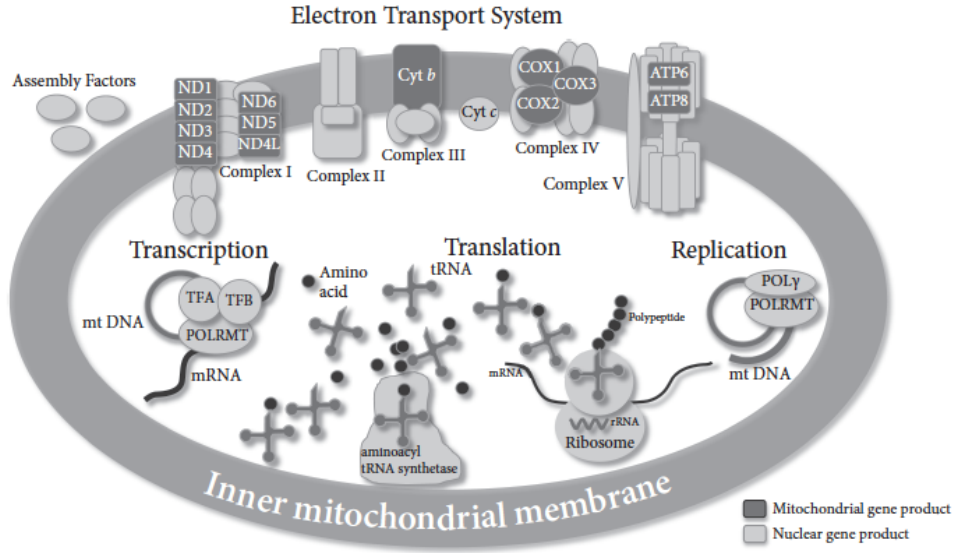
Supercomplexes



Protein-DNA



Hill et al. 2019

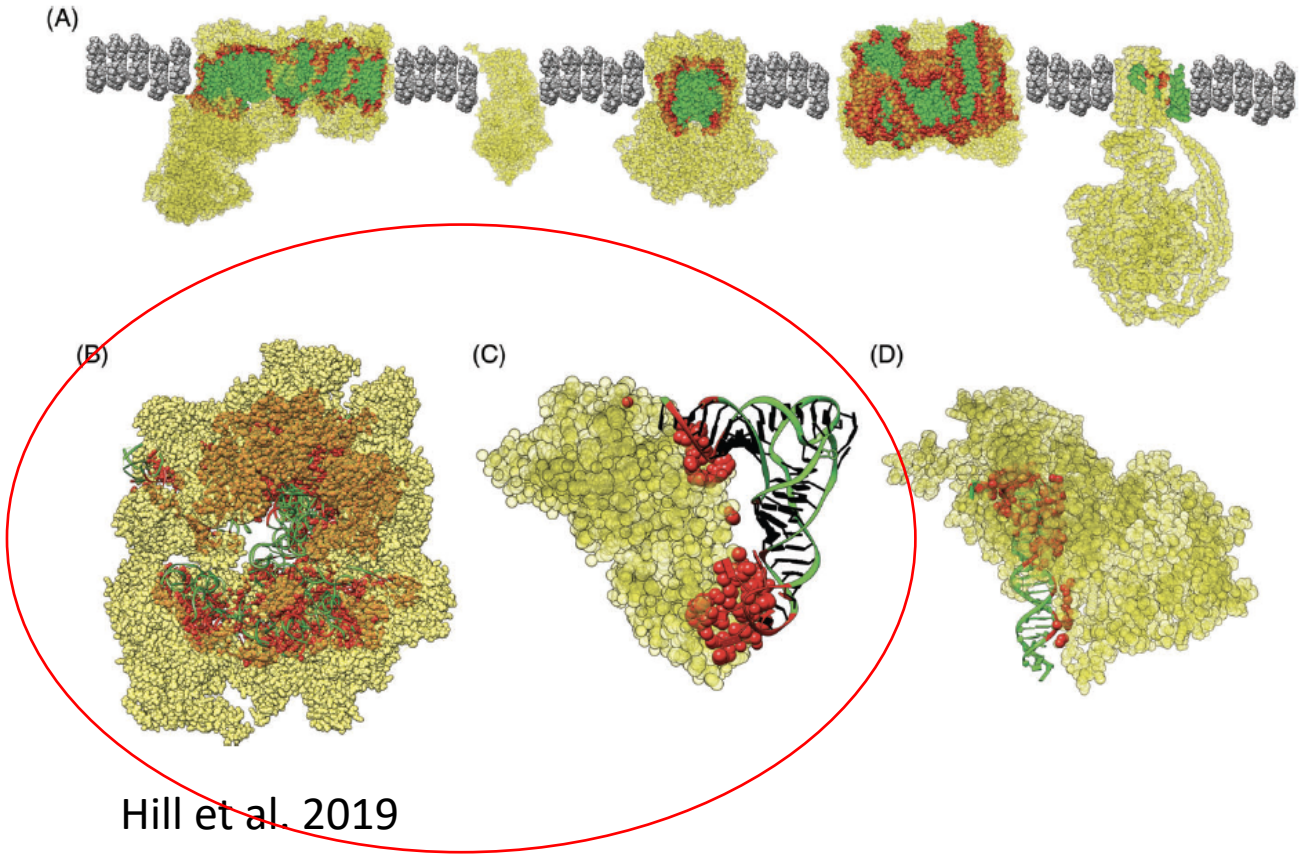


Ellison and Burton 2006

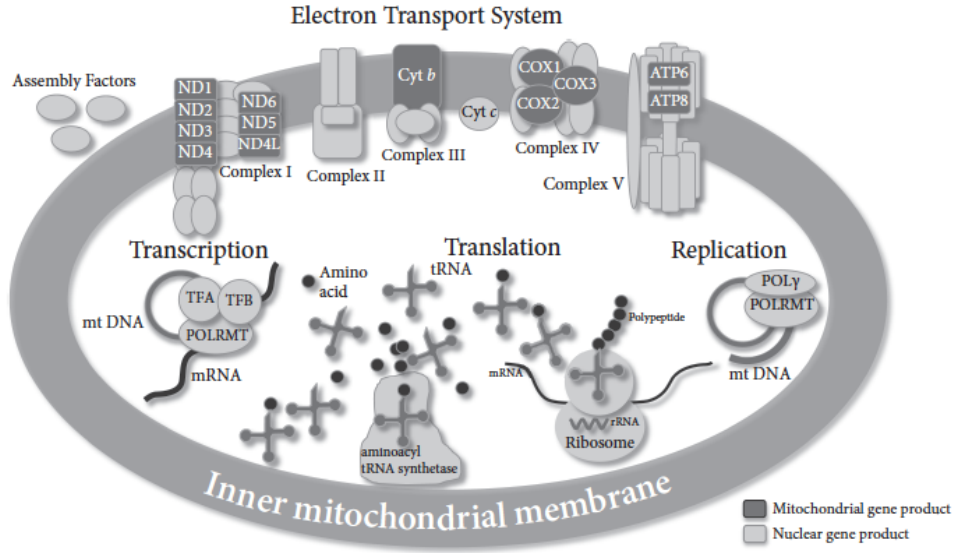
Protein-DNA interactions

Process	Gene Type	Origin	Gene Tally	Gene Products
Transcription	Polymerase and transcriptional factors	N	~5	POLRMT, TFAM, TFB1M, TFB2M, Abf2
Transcription	Initiation sites	mt	~3	HSP1,* HSP2,* LSP*
Transcription	Termination factor		1	mTERF
Replication	Transcriptional initiation sites	mt	2	P H1,* P H2*
Replication	Replication proteins	N	~4	mtSSB, Pol γ, Twinkle, POLRMT

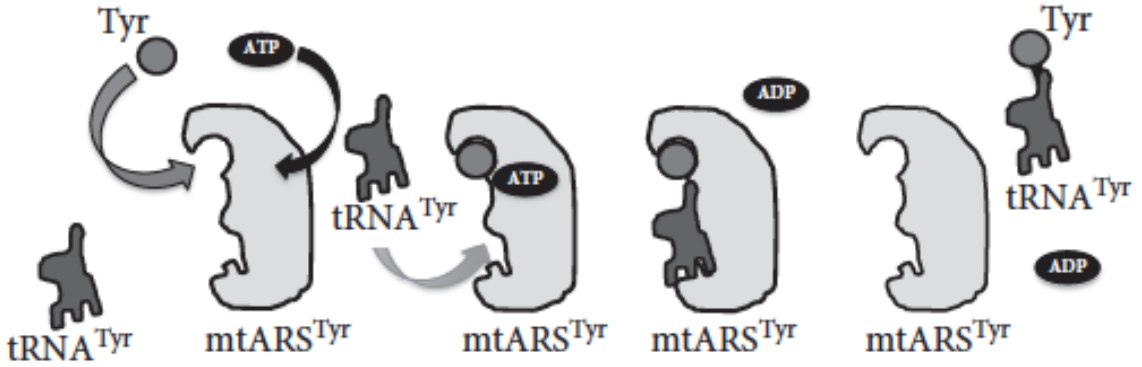
Protein-RNA

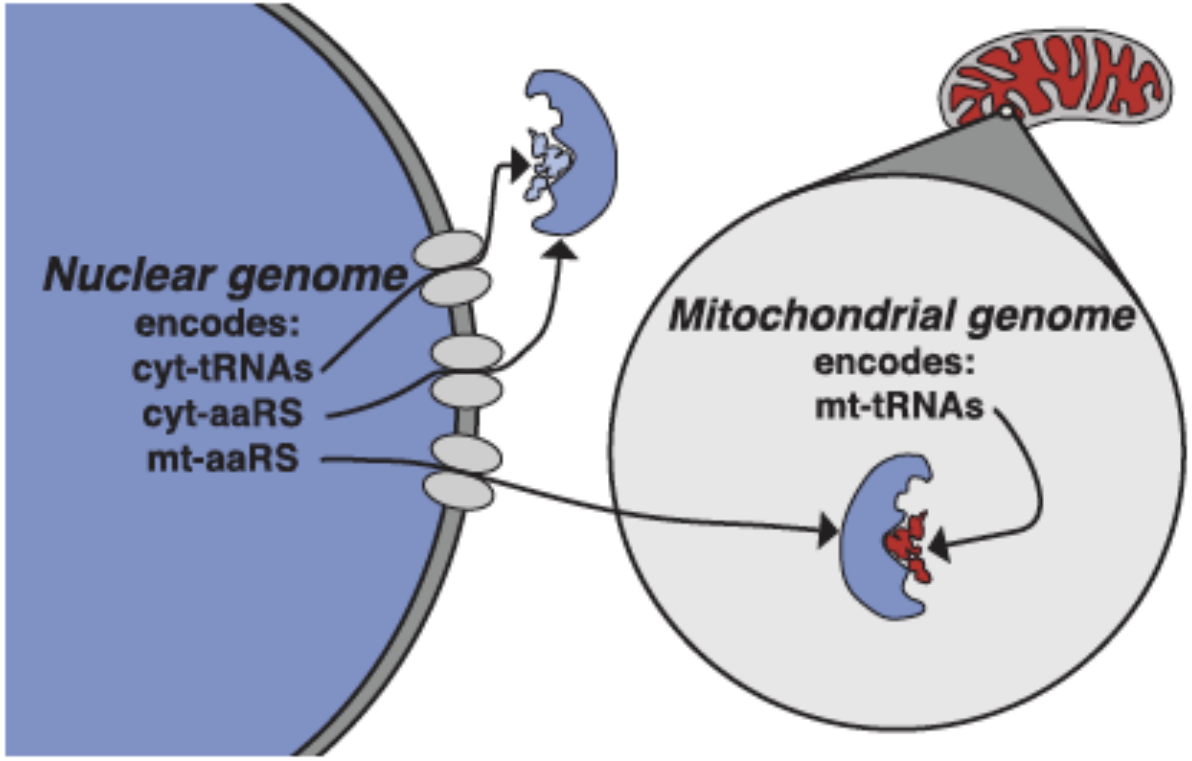


Hill et al. 2019



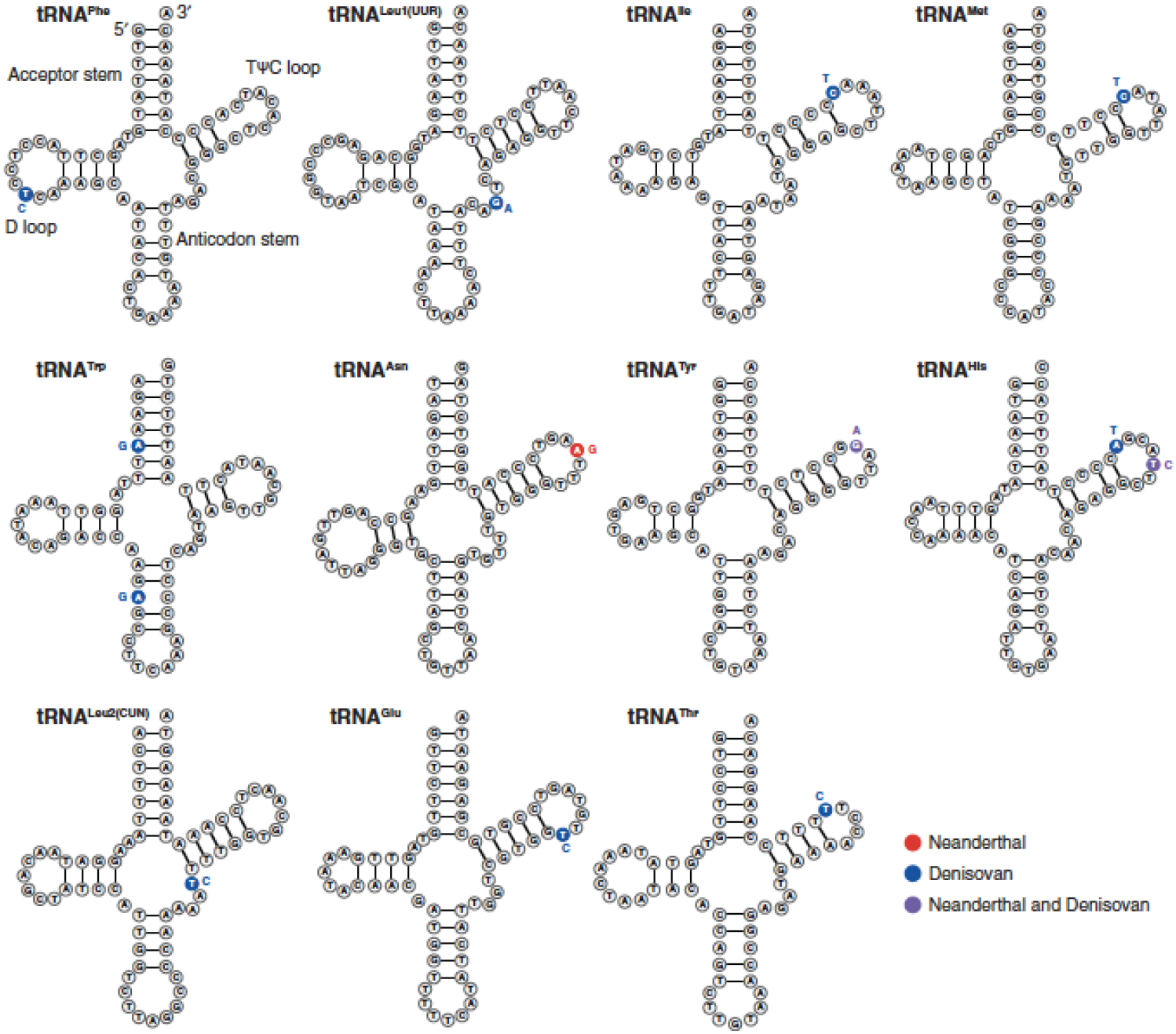
tRNA-tRNA synthetases





Adrion et al. 2015

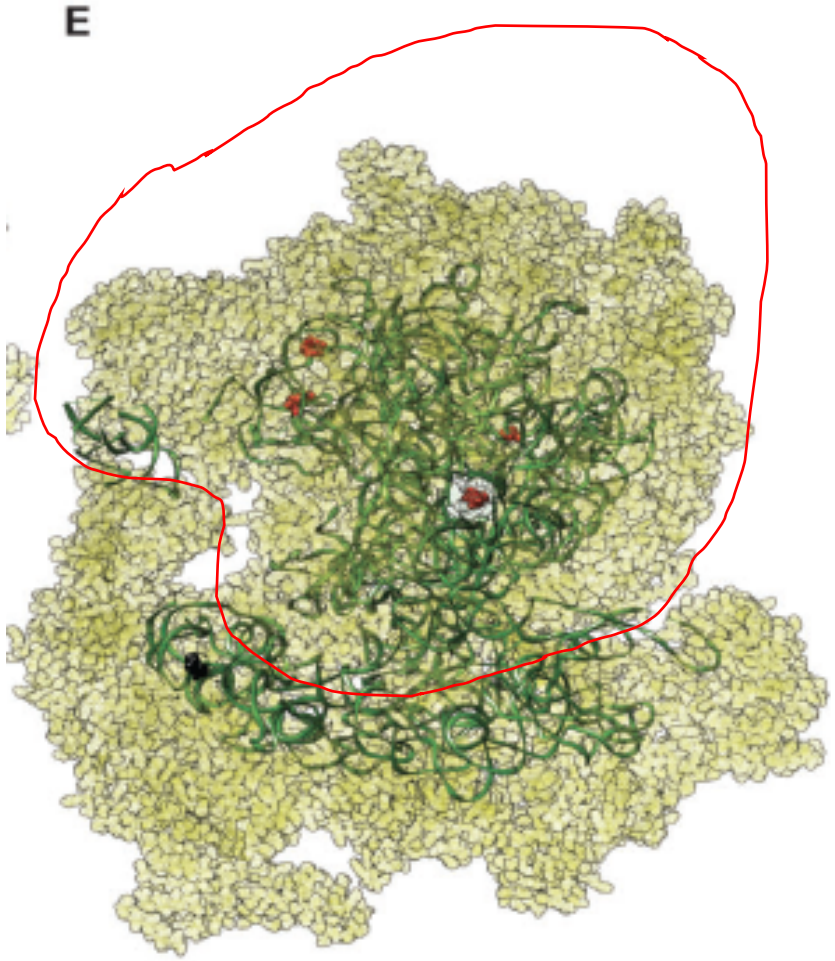
mt tRNAs



Sharbrough et al. 2017

Ribosomal proteins – mt rRNA

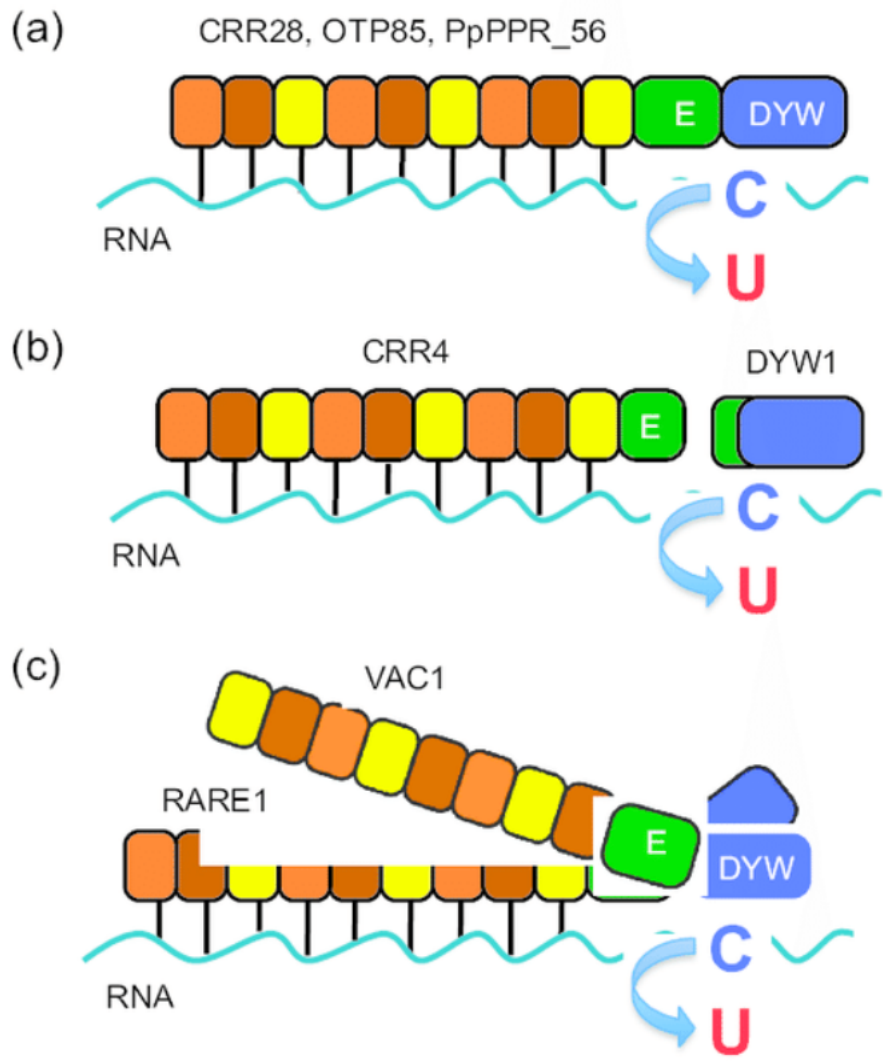
- Also nuc ribosomes with nuc rRNA
- 12S, 16S, 18S, 28S, etc.
- Lots of gains/losses in N proteins



Sharbrough et al. 2017

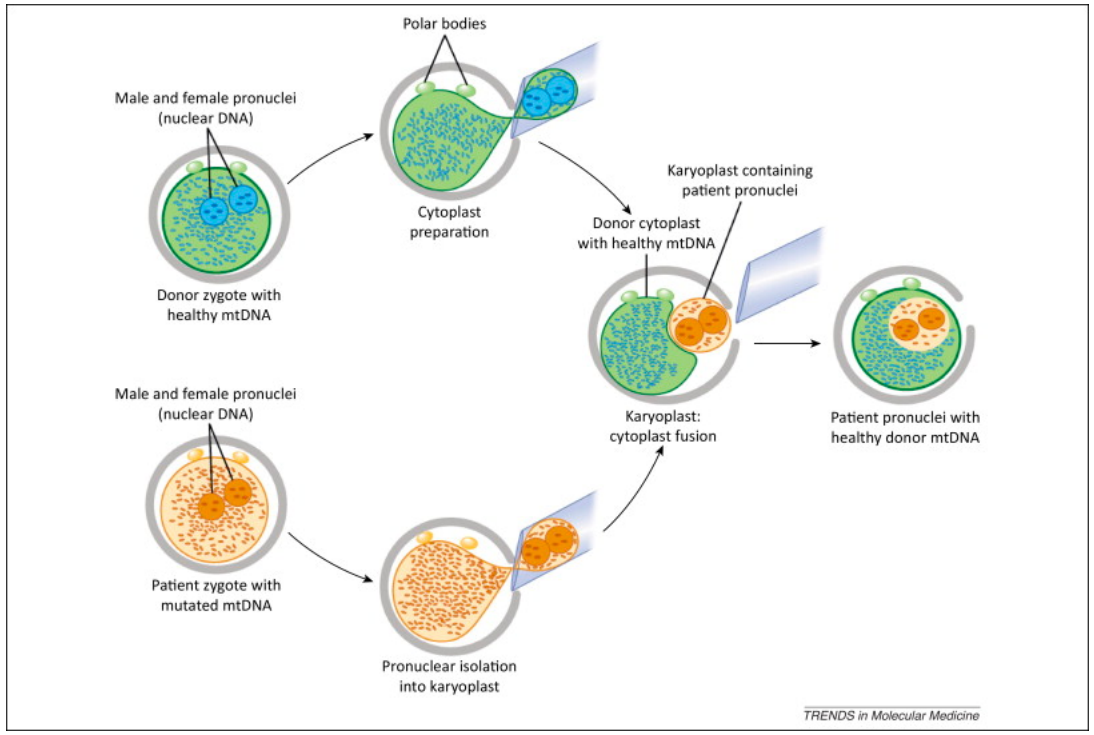
Proteins – mt mRNA

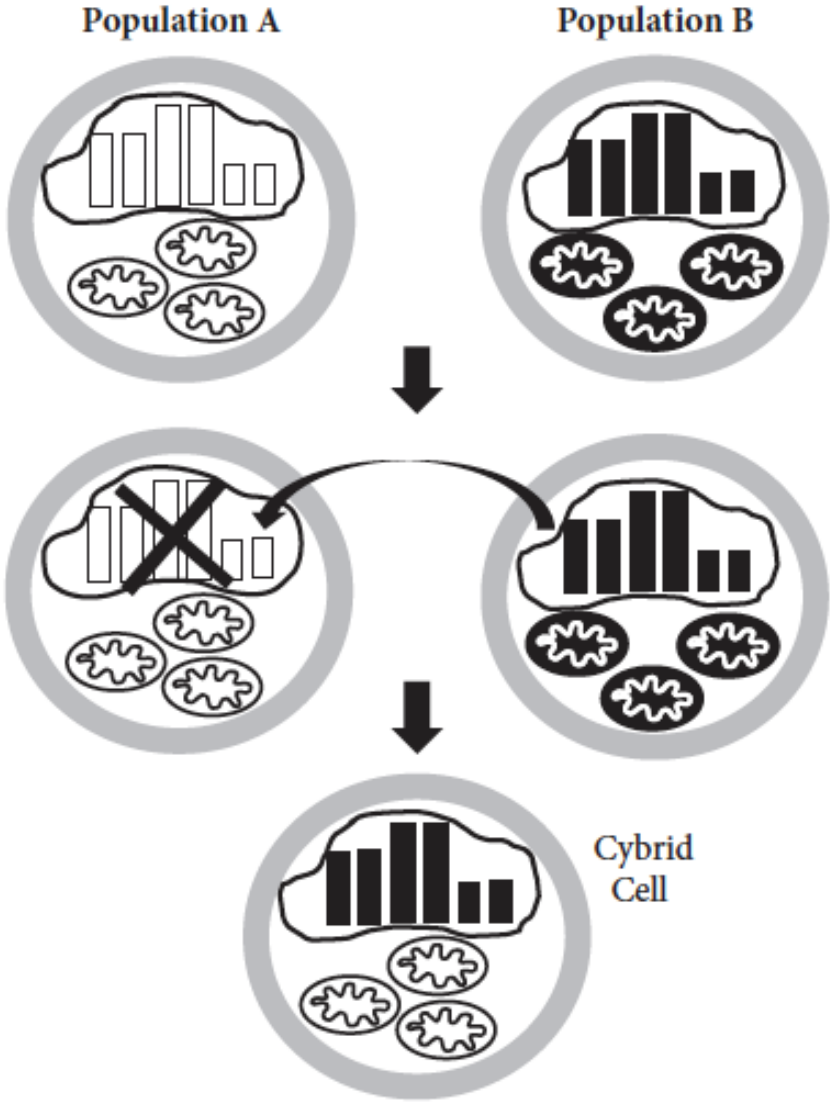
- 100s of PPR proteins
- CMS



Evidence of incompatibilities - mismatching

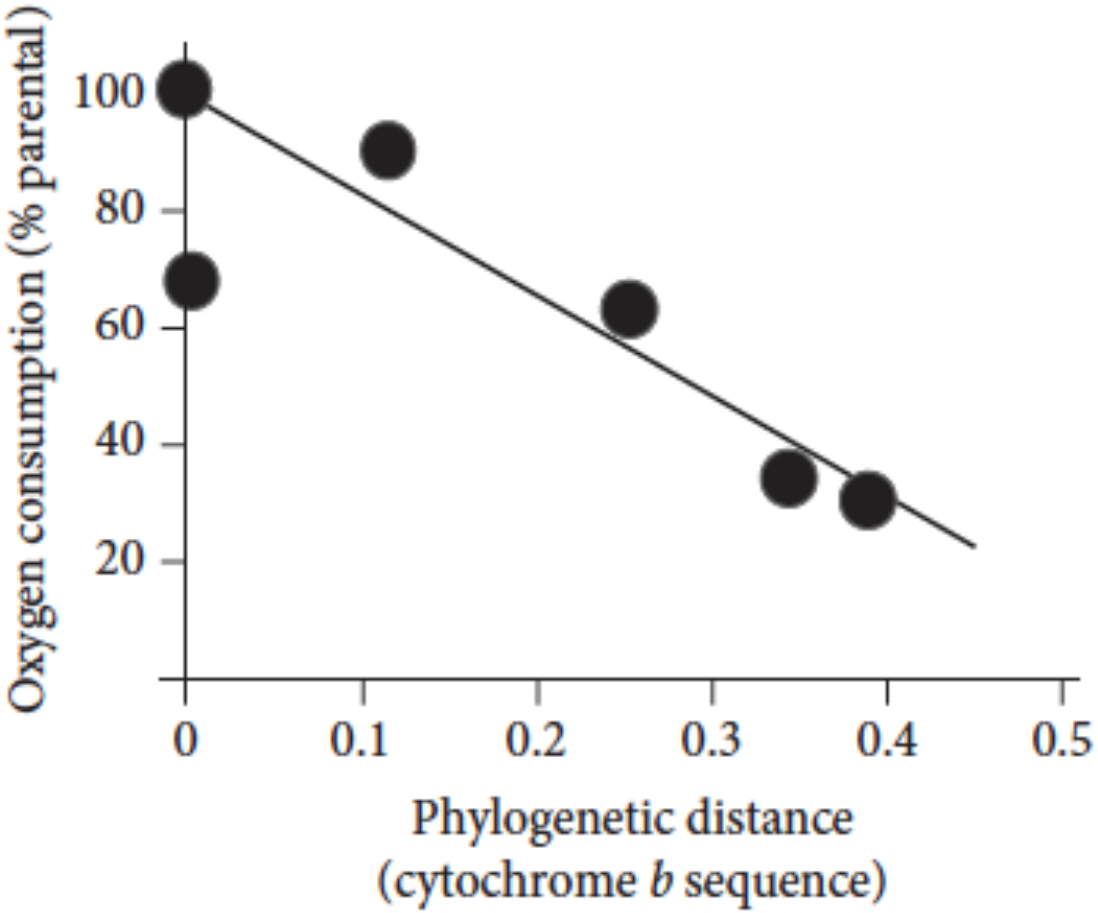
- Cybrids
  - Make a mismatched cell in the lab
- MRT





Cybrids

- Can create mismatches from anything, even non-viable combinations
- Primates, rodents, yeast, model species
- Biomedical

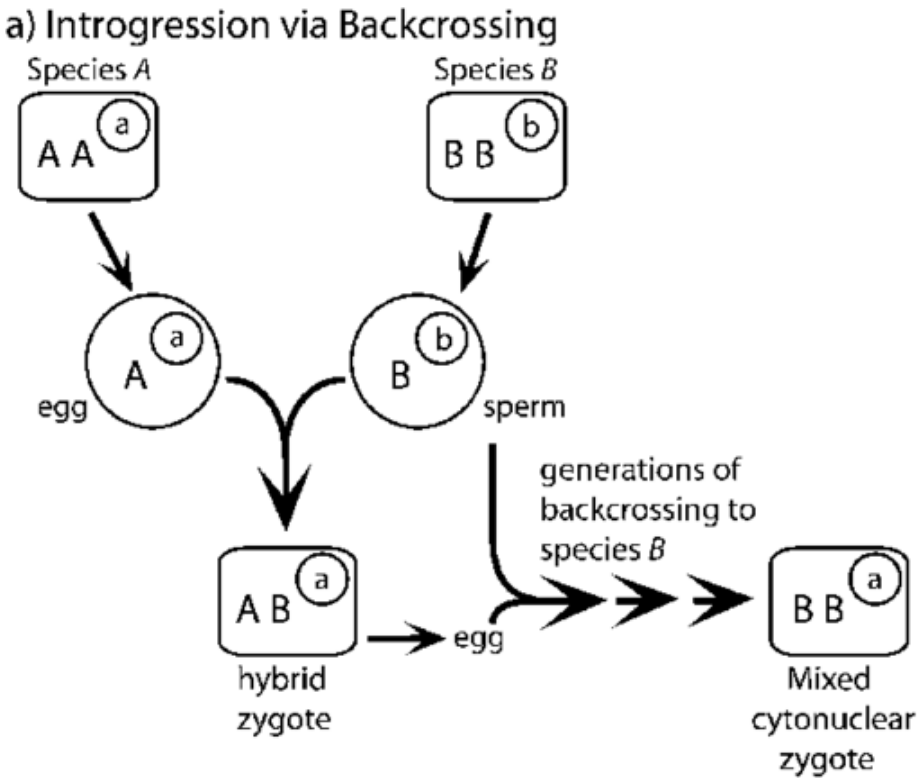


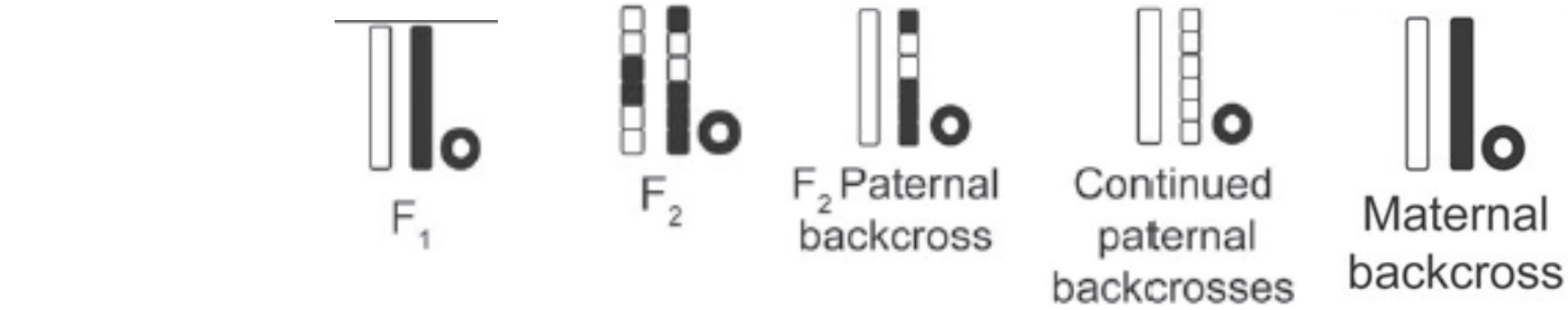
THE WORST THING IN THIS BOOK

individuals with identical N genotypes (hence the army of identical warriors in *Star Wars Clone Wars*). When SCNT has been used to combine a N genome of one species

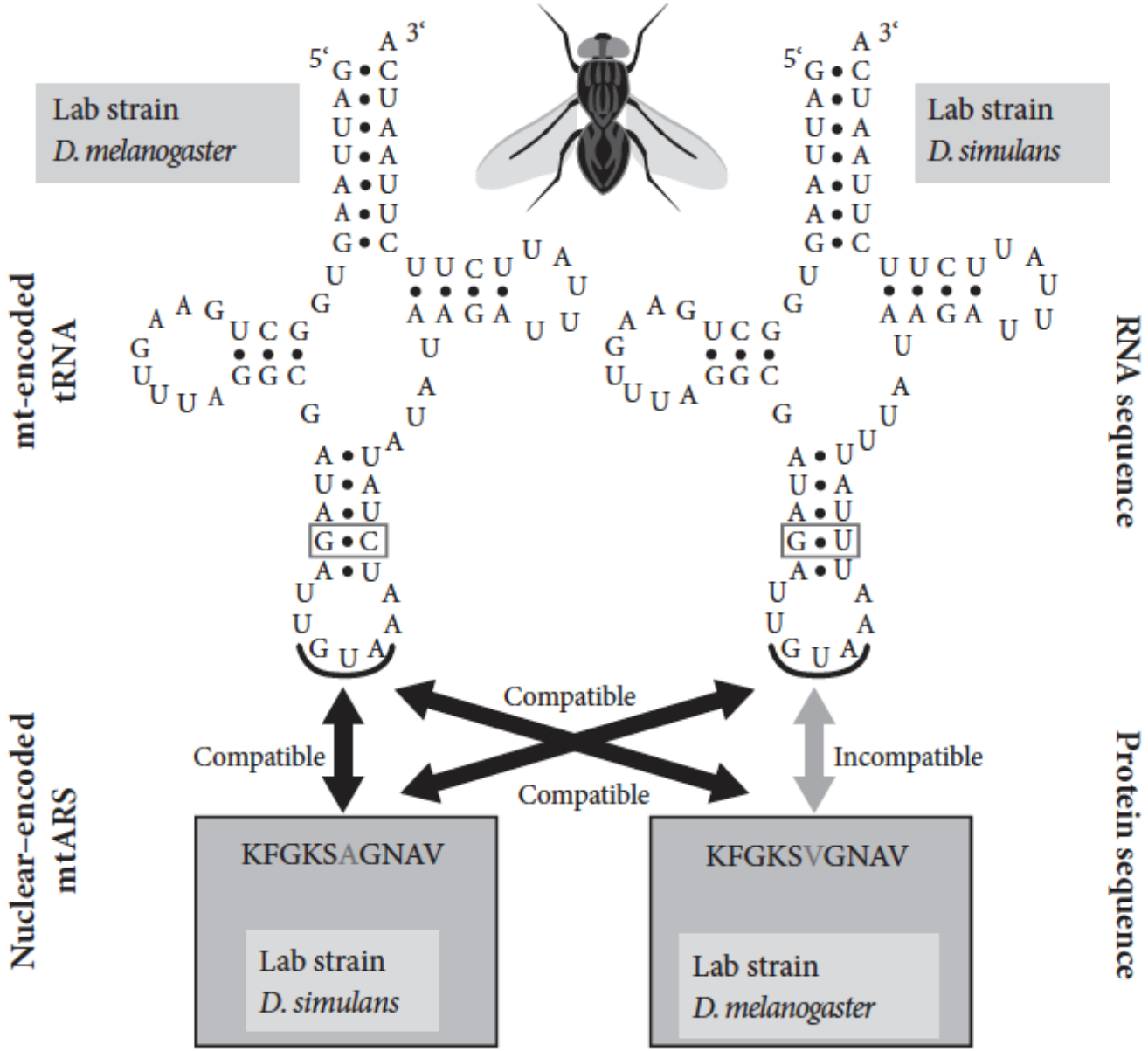
Hybrid parental backcrossing

- Must be reproductively compatible
- More realistic
- Labor intensive
- Subject to selection

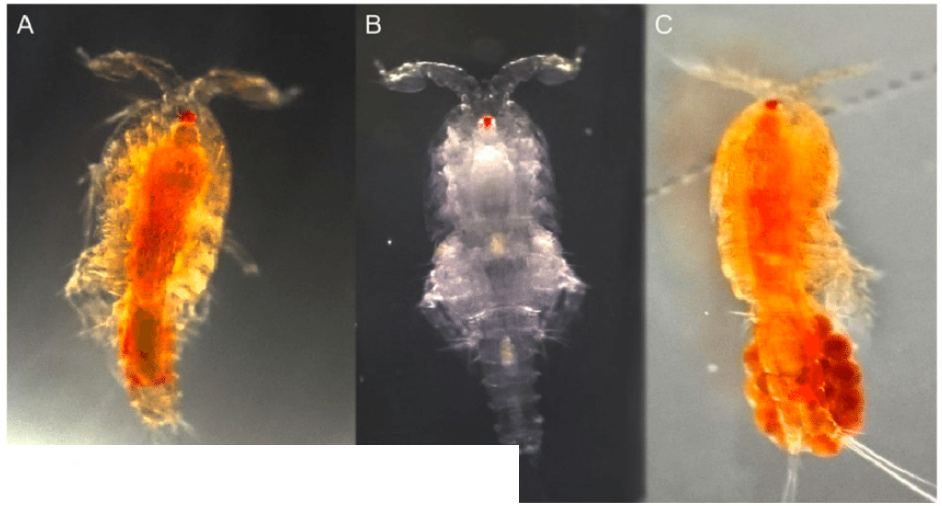


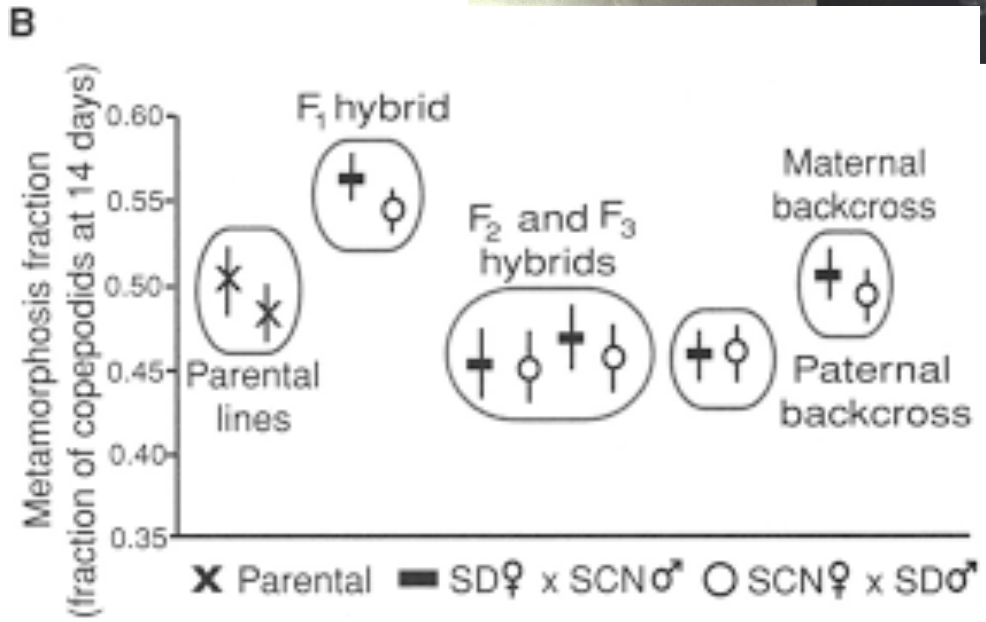


A few examples

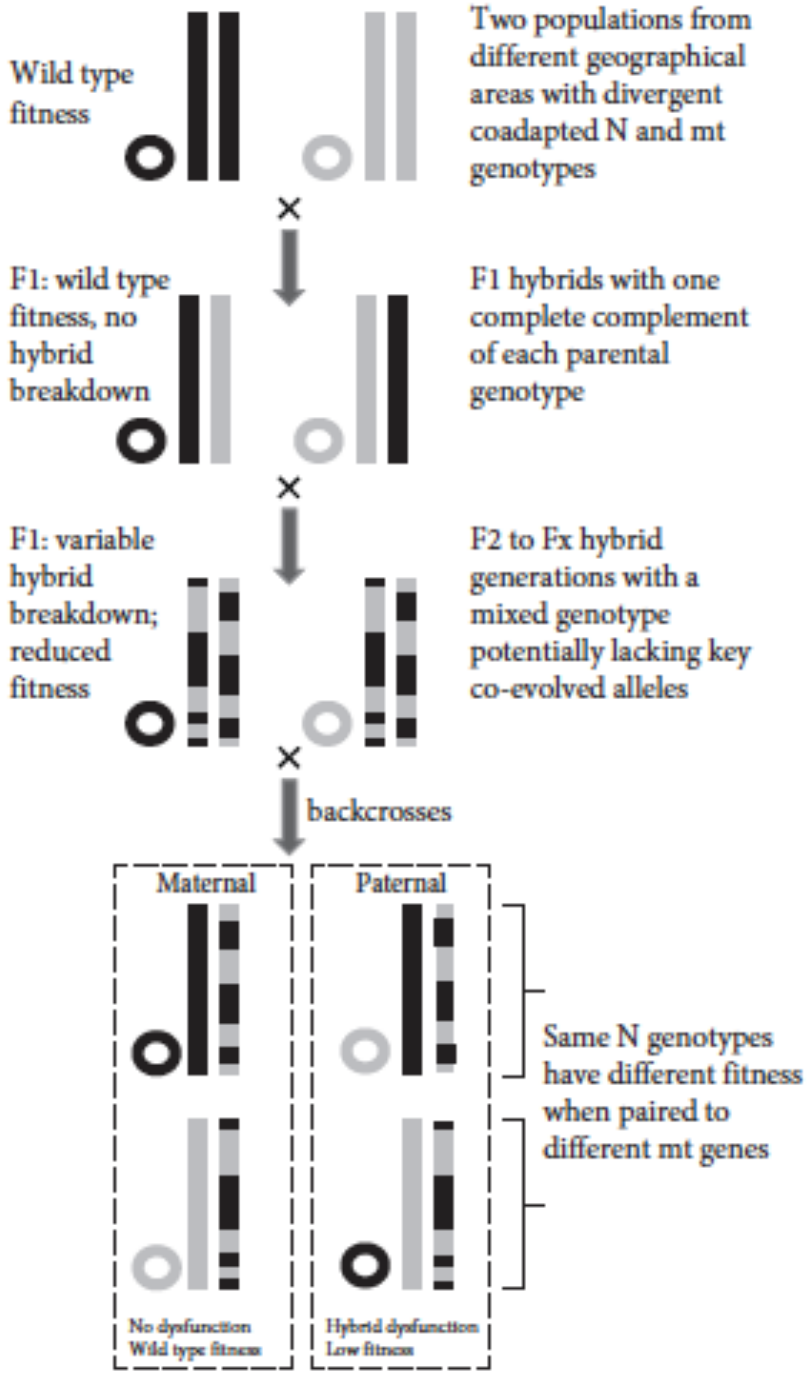


A few examples





Burton, lots of work



Mitonuclear epistasis and DMIs

MOLECULAR ECOLOGY
Molecular Ecology (2012) doi: 10.1111/mec.12006

INVITED REVIEW AND META-ANALYSES

A disproportionate role for mtDNA in Dobzhansky–Muller incompatibilities?

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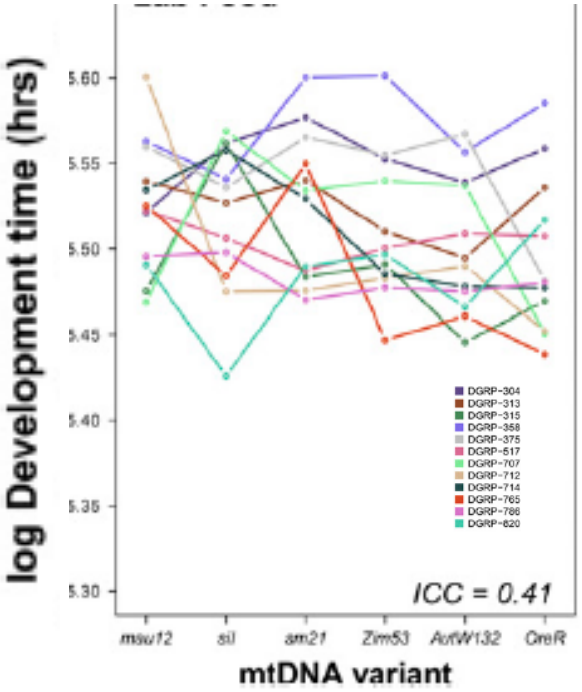
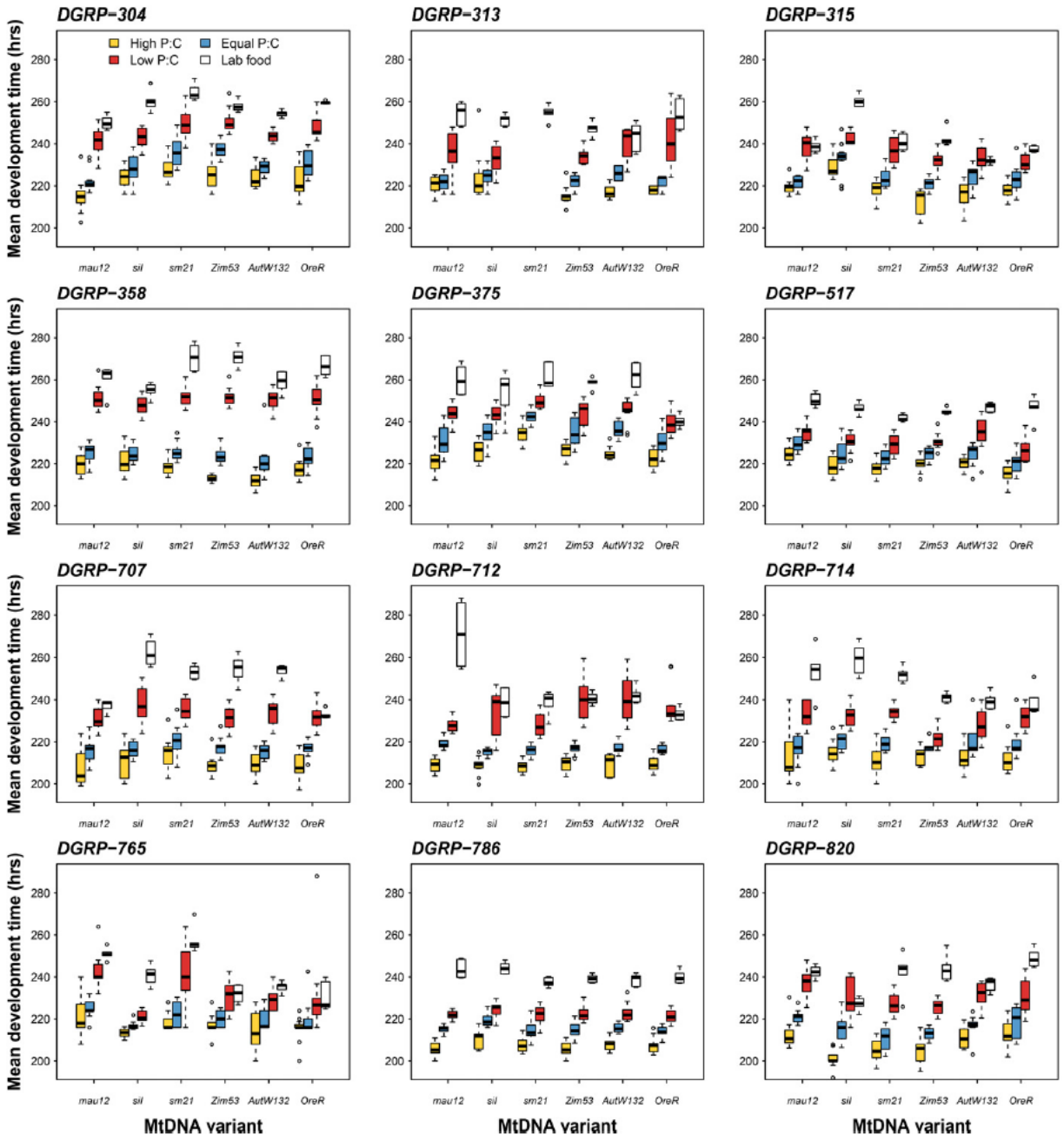
Table 1 Summary of mitonuclear interactions. Although there are many examples of disrupted interactions impacting fitness in the context of human diseases, the potential role of protein–DNA and protein–RNA mitonuclear interactions in Dobzhansky–Muller interactions remains understudied

Mitochondrial function	Dominant interactions	mtDNA- encoded genes	nucDNA- encoded genes	Example studies
ATP production	Protein-protein	13 protein subunits	~75 protein subunits	Many studies of evolutionary rate interactions (e.g., Osada & Akashi 2012), functional interactions and fitness consequences (reviewed by Ballard & Melvin 2010)
Transcription	Protein-DNA	Non-coding control regions (promoters and terminators)	mtRPOL, TFAM, TFB1, TFB2	Functional interactions between mtRPOL and mtDNA: human/mouse (Gaspari *et al.* 2004); copepod populations (Ellison & Burton 2008b)
Replication	Protein-DNA	Non-coding origin of replication	DNA polymerase, mtRPOL, TFAM, helicase, ligase	mtDNA copy number in hybrids: Ellison & Burton (2010)
Translation	Protein-RNA	12S and 16S rRNAs 22 tRNAs	~80 ribosomal proteins 17 aminoacyl tRNA synthases, initiation factors, elongation factors	Translation deficiency in hybrids: Lee *et al.* (2008); poor intron excision: Chou *et al.* (2010); Ribosomal protein divergence: Matthews *et al.* (1978); Pietromonaco *et al.* (1986)



Mossman et al. 2016

G x G x E effects



Mossman et al. 2016