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Metabolism: Cellular Respiration

Printable Flashcards — Pre-Med Biology

Mitochondria structure, glycolysis, pyruvate oxidation, Krebs cycle, ETC, and oxidative phosphorylation.

211 cards — Print double-sided, flip on long edge, then cut along dashed lines.

211 cards — Printable Flashcards

Free & Open-Source

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1

Cellular respiration is basically the process of...

2

Big picture: glucose is broken down into... and energy gets stored in...

3

High-yield order of stages (glucose -> ATP):

4

Where does MOST ATP come from in respiration?

5

Glycolysis makes ATP by...

6

ETC makes ATP by...

7

Oxygen is directly used in...

8

Trap: oxygen is needed for glycolysis to happen. True or false?

2

$CO_2 + H_2O$; ATP (and electron carriers).

1

Getting usable ATP out of food (like glucose).

4

The electron transport chain + ATP synthase (oxidative phosphorylation).

3

Glycolysis -> pyruvate oxidation -> Krebs (TCA) -> ETC/oxidative phosphorylation.

6

Oxidative phosphorylation (chemiosmosis).

5

Substrate-level phosphorylation.

8

False.

7

The ETC (as the final electron acceptor).

9

NAD^+ / NADH are basically...

10

Oxidation vs reduction (quick sanity check):

11

Respiration is 'oxidizing' glucose.
That means glucose is...

12

Why do cells bother making NADH/FADH2 instead of just making tons of ATP directly?

13

Cellular respiration happens only in animals. True or false?

14

If a question says 'aerobic respiration', the key extra thing present is...

15

If a question says 'anaerobic', don't panic. Usually they mean...

16

Respiration stages: {{c1::glycolysis}} -> {{c2::pyruvate oxidation}} -> {{c3::Krebs}} -> {{c4::ETC}}.

10

Oxidation = lose electrons.
Reduction = gain electrons.

9

Electron carriers: NAD^+ is empty,
NADH is loaded (high-energy electrons).

12

Because carriers let the cell extract
energy step-by-step efficiently.

11

Losing electrons (getting broken down).

14

Oxygen at the end of the ETC.

13

False.

16

Respiration stages: glycolysis ->
pyruvate oxidation -> Krebs -> ETC.

15

No oxygen -> fermentation is
used to keep glycolysis going.

17

Final electron acceptor in aerobic respiration:

18

Mitochondria are the main site of... (in eukaryotes)

19

Mitochondria have TWO membranes: outer and inner. The inner membrane is special because...

20

Cristae are...

21

Matrix is...

22

Intermembrane space is...

23

ETC proteins are located in the...

24

Krebs cycle enzymes are located in the...

18

Aerobic ATP production (Krebs + ETC).

17

Oxygen (O2)

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20

Folds of the inner mitochondrial membrane.

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19

It's folded (cristae) and packed with the ETC and ATP synthase.

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22

The space between outer and inner mitochondrial membranes.

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21

The fluid space inside the inner membrane.

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24

Mitochondrial matrix.

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23

Inner mitochondrial membrane.

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25

Glycolysis happens in the...

26

In mitochondria, protons get pumped from the matrix to the...

27

So where is the H^+ concentration HIGH during oxidative phosphorylation?

28

ATP synthase makes ATP when H^+ flows...

29

Trap: mitochondria pump protons into the matrix to make ATP. True or false?

30

Outer mitochondrial membrane is relatively... (permeable or not?)

31

Inner mitochondrial membrane is... (permeable or not?)

32

Why does the ETC need a membrane?

26

Intermembrane space.

25

Cytosol (cytoplasm).

28

From intermembrane space back into the matrix.

27

Intermembrane space.

30

Permeable to small molecules
(more than inner membrane).

29

False.

32

To separate charges and build a proton gradient.

31

Very selective (keeps the proton gradient).

33

Mitochondria have their own DNA. Why is that a big hint about their origin?

34

Trap: Only animal cells have mitochondria. True or false?

35

Cells with high energy demand usually have...

36

Prokaryotes (bacteria) don't have mitochondria. So where is their ETC?

37

Quick compare trap: proton build-up location - mitochondria vs chloroplasts.

38

Locations: glycolysis = {{c1::cytosol}}; Krebs cycle = {{c2::mitochondrial matrix}}; ETC = {{c3::inner mitochondrial membrane}}.

39

Space where H^+ builds up in mitochondria during ETC:

40

Glycolysis literally means...

34

False.

33

It supports endosymbiosis (they likely came from bacteria).

36

In the plasma membrane.

35

More mitochondria.

38

Locations: glycolysis = cytosol; Krebs cycle = mitochondrial matrix; ETC = inner mitochondrial membrane.

37

Mito: intermembrane space. Chloro: thylakoid lumen.

40

Splitting sugar (glucose) into smaller molecules.

39

Intermembrane space

41

Where does glycolysis happen?

42

Does glycolysis require oxygen?

43

One glucose becomes... pyruvate.

44

Net ATP from glycolysis per glucose is...

45

Glycolysis makes 4 ATP total. So why isn't the answer '4 ATP'?

46

Glycolysis produces electron carriers too:

47

Glycolysis also produces... (gas trap)

48

Glycolysis has two phases:

42

No.

41

In the cytosol.

44

2 ATP net.

43

Two pyruvate.

46

2 NADH per glucose.

45

Because 2 ATP are invested first, so net is 2.

48

Investment phase (spend ATP) and payoff phase (make ATP/NADH).

47

No CO2 directly.

49

Why does glycolysis spend ATP at the start?

50

The ATP made in glycolysis is made by...

51

Why is NAD^+ needed for glycolysis?

52

In aerobic conditions, NADH from glycolysis is eventually used to...

53

In anaerobic conditions, NAD^+ is regenerated mainly by...

54

Fermentation's #1 goal is...

55

In human cells, the main fermentation product is...

56

In yeast (bread/beer), fermentation produces...

50

Substrate-level phosphorylation (direct phosphate transfer).

49

To 'prime' glucose and make it reactive enough to split and harvest energy.

52

Feed electrons into the ETC (after being shuttled into mitochondria).

51

To accept electrons so the pathway can keep running.

54

Regenerate NAD^+.

53

Fermentation.

56

Ethanol + CO2.

55

Lactate (lactic acid).

57

Trap: fermentation happens in mitochondria. True or false?

58

Glycolysis is basically the 'backup plan' for ATP when...

59

Why do sprinting muscles make lots of lactate?

60

Glycolysis happens in almost all cells because...

61

If a cell has no mitochondria (like mature RBCs), it gets ATP mainly from...

62

What happens to pyruvate in aerobic conditions?

63

What happens to pyruvate when oxygen is low (humans)?

64

Trap: lactate is a 'waste product' with no purpose. True or false?

58

Oxygen is limited or ATP is needed fast.

57

False.

60

It's ancient, cytosolic, and doesn't require oxygen.

59

Oxygen delivery can't keep up, so fermentation regenerates NAD^+ to keep glycolysis running.

62

It enters mitochondria and becomes acetyl-CoA (then Krebs).

61

Glycolysis.

64

False.

63

It becomes lactate to regenerate NAD^+.

65

Key enzyme control point of glycolysis (pre-med favorite):

66

PFK-1 is inhibited when the cell has lots of...

67

PFK-1 is activated when the cell has lots of...

68

Trap: glycolysis happens only when oxygen is absent. True or false?

69

If glycolysis is blocked, what happens first: loss of ATP from glycolysis or loss of ATP from ETC?

70

Glycolysis can be thought of as: glucose ->

71

Net glycolysis per glucose: {{c1::2 ATP}} + {{c2::2 NADH}} + {{c3::2 pyruvate}}.

72

Glycolysis happens in the {{c1::cytosol}} and does {{c2::not}} require oxygen.

66

ATP (high energy).

65

PFK-1 (phosphofructokinase-1).

68

False.

67

AMP (low energy signal).

70

Pyruvate + a little ATP + NADH.

69

You lose the initial ATP and also starve the mitochondria of pyruvate/electrons downstream.

72

Glycolysis happens in the cytosol and does not require oxygen.

71

Net glycolysis per glucose: 2 ATP + 2 NADH + 2 pyruvate.

73

Net ATP from glycolysis (per glucose):

74

Main fermentation product in humans:

75

Which stage of respiration can happen without mitochondria?

76

Why is glycolysis called 'inefficient' compared to aerobic respiration?

77

If oxygen suddenly becomes available after anaerobic glycolysis, lactate can be...

78

Trap: lactate formation produces extra ATP. True or false?

79

Why do red blood cells not want mitochondria (concept)?

80

Pyruvate is the end product of...

74

Lactate

73

2

76

It leaves a lot of energy still stored in pyruvate/lactate.

75

Glycolysis (and fermentation).

78

False.

77

Converted back to pyruvate and used in aerobic metabolism.

80

Glycolysis.

79

So they don't use the oxygen they're carrying.

81

Pyruvate is a... carbon molecule.

82

Pyruvate is basically the 'decision point' because it can go to...

83

Aerobic fate of pyruvate:

84

Anaerobic fate of pyruvate in humans:

85

Anaerobic fate of pyruvate in yeast:

86

Pyruvate oxidation is also called the... reaction.

87

Where does pyruvate oxidation happen (eukaryotes)?

88

Pyruvate oxidation converts pyruvate into...

82

Aerobic path (acetyl-CoA -> Krebs) OR anaerobic path (fermentation).

81

3-carbon molecule.

84

Pyruvate -> lactate.

83

Pyruvate -> acetyl-CoA (in mitochondria) -> Krebs cycle.

86

Link (bridge) reaction.

85

Pyruvate -> ethanol + CO_2.

88

Acetyl-CoA.

87

Mitochondrial matrix.

89

Pyruvate oxidation also produces...
(two things besides acetyl-CoA)

90

Trap: CO2 is produced during glycolysis. True or false?

91

Acetyl-CoA is a... carbon unit.

92

Why is it called 'acetyl-CoA' and not just 'acetyl'?

93

The enzyme complex that does pyruvate -> acetyl-CoA is...

94

In aerobic metabolism, where do the carbons of glucose end up?

95

In lactate fermentation, is CO2 released?

96

In alcohol fermentation, CO2 is released because...

90

False (in aerobic respiration).

89

NADH and CO_2.

92

CoA is the carrier that holds the acetyl group and makes it reactive.

91

2-carbon unit (acetyl group).

94

As CO_2 (released in pyruvate oxidation + Krebs).

93

Pyruvate dehydrogenase (PDH) complex.

96

Pyruvate loses a carbon as CO_2 on the way to ethanol.

95

No (in humans, lactate fermentation doesn't release CO_2).

97

Why can't pyruvate just enter the Krebs cycle directly?

98

If oxygen is absent, why does the Krebs cycle slow down/stop?

99

So without oxygen, what can still produce ATP quickly?

100

Cori cycle (basic idea): lactate from muscles can be sent to the... to be turned back into glucose.

101

Trap: pyruvate oxidation happens in the cytosol. True or false?

102

Pyruvate (3C) -> {{c1::acetyl-CoA}} (2C) + {{c2::CO2}} + {{c3::NADH}}.

103

Bridge step between glycolysis and Krebs:

104

Krebs cycle is also called the...

98

Because NADH can't be oxidized back to NAD^+ by the ETC, so NAD^+ runs low.

97

Krebs cycle runs on acetyl-CoA (2C), not pyruvate (3C).

100

Liver.

99

Glycolysis (if NAD^+ is regenerated by fermentation).

102

Pyruvate (3C) -> acetyl-CoA (2C) + CO2 + NADH.

101

False.

104

Citric acid cycle or TCA cycle.

103

Pyruvate oxidation (link reaction)

105

Where does the Krebs cycle happen (eukaryotes)?

106

Krebs cycle starts when acetyl-CoA combines with...

107

Why is it called a cycle?

108

Main job of the Krebs cycle is to...

109

Does the Krebs cycle use oxygen directly?

110

Krebs cycle produces CO2.
Does glycolysis produce CO2?

111

Per acetyl-CoA, Krebs cycle produces:

112

Per glucose, Krebs cycle
produces (because 2 acetyl-CoA):

106

Oxaloacetate to form citrate.

105

Mitochondrial matrix.

108

Harvest high-energy electrons (NADH/FADH2) while turning acetyl-CoA into CO2.

107

Because oxaloacetate is regenerated at the end.

110

Krebs: yes. Glycolysis: no.

109

No.

112

6 NADH, 2 FADH2, 2 GTP (ATP), and 4 CO2.

111

3 NADH, 1 FADH2, 1 GTP (ATP), and 2 CO2.

113

Why does $FADH_2$ usually give less ATP than NADH?

114

The only ATP made directly in the Krebs cycle is made by...

115

GTP is basically... (for pre-med exams)

116

Trap: acetyl-CoA goes into the ETC to make ATP. True or false?

117

If the ETC stops (no O_2), what happens to Krebs cycle?

118

Krebs cycle is sometimes described as 'amphibolic' meaning...

119

One enzyme that shows up in BOTH Krebs and ETC (hard but common trap) is...

120

If a question asks 'where is CO_2 released from glucose breakdown?', the correct stages are...

114

Substrate-level phosphorylation (as GTP/ATP).

113

It enters the ETC later (so fewer protons are pumped).

116

False.

115

An ATP-equivalent energy molecule.

118

It connects breakdown and building pathways (not just energy).

117

It slows/stops because NAD^+ and FAD aren't regenerated.

120

Pyruvate oxidation and Krebs cycle.

119

Succinate dehydrogenase (it's also Complex II).

121

Krebs cycle is basically the stage where you...

122

If you see 'dehydrogenase' in a pathway name, it's usually doing...

123

Krebs cycle location (eukaryotes): {{c1::mitochondrial matrix}}.

124

Per acetyl-CoA, Krebs makes {{c1::3 NADH}}, {{c2::1 FADH2}}, {{c3::1 GTP}}, and {{c4::2 CO2}}.

125

Another name for Krebs cycle:

126

When a cell has HIGH ATP and lots of NADH, Krebs cycle tends to...

127

When a cell has LOW ATP (high ADP/AMP) and lots of NAD^{+}, Krebs cycle tends to...

128

Why does NADH build-up slow the Krebs cycle?

122

Oxidation (removing H/electrons) and making NADH or FADH2.

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121

Strip electrons off acetyl-CoA and load them onto NADH/FADH2.

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124

Per acetyl-CoA, Krebs makes 3 NADH, 1 FADH2, 1 GTP, and 2 CO2.

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123

Krebs cycle location (eukaryotes): mitochondrial matrix.

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126

Slow down.

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125

Citric acid cycle

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128

Because NAD^+ becomes scarce (and NAD^+ is needed to accept electrons).

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127

Speed up.

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129

Rate-limiting idea: the Krebs cycle is limited by...

130

If oxygen supply drops, which stage 'feels it' first in terms of stopping electron flow?

131

ETC stands for...

132

ETC's main job is to...

133

Where is the ETC located (eukaryotes)?

134

What molecules donate electrons to the ETC?

135

What is the final electron acceptor in the ETC?

136

Trap: oxygen is used to make CO2 in respiration. True or false?

130

The ETC (because O2 is the final acceptor).

129

How fast NADH/FADH2 can be re-oxidized by the ETC.

132

Use electron energy to pump protons (H^+) and build a gradient.

131

Electron Transport Chain.

134

NADH and FADH2.

133

Inner mitochondrial membrane.

136

False.

135

Oxygen (O2).

137

In aerobic respiration, oxygen ends up as...

138

Why is oxygen so important to keep respiration going?

139

What happens if oxygen is removed?

140

What does 'oxidative phosphorylation' mean?

141

Chemiosmosis means...

142

In mitochondria, protons are pumped into the... and flow back to the...

143

ATP synthase is basically...

144

Trap: ATP synthase pumps protons to make ATP. True or false?

138

Because it keeps electrons flowing by accepting them at the end.

137

Water (H2O).

140

Making ATP using energy from oxidation of NADH/FADH2 via the ETC.

139

ETC stops -> NADH builds up -> Krebs/pyruvate oxidation slow -> glycolysis needs fermentation to continue.

142

Intermembrane space; matrix.

141

ATP synthesis powered by a proton gradient.

144

False.

143

A protein turbine that makes ATP when H^+ flows through it.

145

NADH gives more ATP than FADH2 because...

146

Quick trap: Complex II does NOT...

147

If you had to name the proton-pumping complexes, they are... (hard)

148

Mobile electron carriers in the ETC include... (hard)

149

Why do cristae matter for ATP production?

150

What is the 'proton motive force'? (simple)

151

If the inner membrane becomes leaky to H^+, ATP production...

152

Uncoupling means...

146

Pump protons.

145

NADH electrons enter earlier in the ETC and drive more proton pumping.

148

Ubiquinone (CoQ) and cytochrome c.

147

Complex I, III, and IV.

150

Stored energy in the H^+ gradient (concentration + charge).

149

They increase inner membrane surface area to fit more ETC and ATP synthase.

152

Electron transport continues but ATP synthesis drops because the gradient is lost.

151

Drops (gradient collapses).

153

Scenario: If someone takes an uncoupler, oxygen consumption tends to... while ATP production...

154

Why does blocking the ETC quickly hurt ATP supply?

155

Scenario: If Complex IV is blocked, what happens to electron flow and oxygen use?

156

When NADH donates electrons to the ETC, NADH becomes...

157

So oxygen indirectly keeps glycolysis and Krebs going because it...

158

ETC is called an 'electron transport chain' because electrons are passed...

159

Where do the protons that make the gradient mostly come from?

160

ATP synthase uses ADP + Pi to make...

154

Because oxidative phosphorylation makes most ATP.

153

Increase; decrease.

156

NAD^+.

155

Electron flow stops and oxygen can't accept electrons.

158

From one carrier/complex to the next, down an energy gradient.

157

Allows NADH to be oxidized back to NAD^+.

160

ATP.

159

From the matrix and from water/oxidation reactions (high-level).

161

ATP synthase makes ATP on which side of the inner membrane?

162

ATP made in the matrix is useful for the whole cell because mitochondria can...

163

Trap: the outer mitochondrial membrane maintains the proton gradient. True or false?

164

If ATP synthase is blocked but ETC still runs, what builds up a lot?

165

Why can't ETC just pump protons forever?

166

If a question says 'ATP synthase uses the proton gradient', the keyword they want is...

167

ETC happens only in mitochondria. True or false?

168

Why does FADH2 enter later than NADH (concept)?

162

Export ATP to the cytosol (and import ADP).

161

Matrix side.

164

A huge proton gradient (until it slows the ETC).

163

False.

166

Chemiosmosis.

165

Because the gradient pushes back
(it gets harder to pump against).

168

FADH2 donates electrons at Complex II,
which feeds into the chain after Complex I.

167

False.

169

Trap: NADH and FADH2 carry energy by storing ATP inside them. True or false?

170

If someone says 'NADH is oxidized', that means NADH...

171

If someone says 'O2 is reduced', that means O2...

172

Scenario: No oxygen. Which molecule builds up a lot first: NAD^+ or NADH?

173

Scenario: No oxygen. Which molecule becomes scarce: NAD^+ or NADH?

174

Scenario: If NAD^+ runs low, which pathway hits a wall fast?

175

So fermentation is basically the solution to which problem?

176

Lactate fermentation is basically: pyruvate gets... and NADH gets...

170

Loses electrons and becomes NAD^+.

169

False.

172

NADH.

171

Gains electrons (and forms water).

174

Glycolysis (and also Krebs).

173

NAD^+.

176

Reduced to lactate; oxidized to NAD^+.

175

Low NAD^+ when oxygen is low.

177

ATP made directly (substrate-level) during respiration comes from...

178

Per glucose, substrate-level phosphorylation gives you... (basic)

179

In anaerobic conditions (humans), the ATP per glucose is basically...

180

So why do cells prefer aerobic respiration when possible?

181

If a multiple-choice question asks for total ATP per glucose, the safest answer style is...

182

Older textbooks sometimes say 36-38 ATP per glucose. What's the best pre-med strategy?

183

Easy marks: Which stage produces the most ATP?

184

NADPH vs NADH: which one is mainly for biosynthesis (building)?

178

2 ATP from glycolysis + 2 GTP/ATP from Krebs (total ~4 direct).

177

Glycolysis and the Krebs cycle.

180

It extracts way more ATP per glucose than glycolysis alone.

179

2 ATP (from glycolysis only).

182

Know WHY it's variable, and pick the option that matches the exam's style (usually a range).

181

A range (~30-32 ATP in eukaryotes) rather than one perfect number.

184

NADPH.

183

ETC/oxidative phosphorylation.

185

Trap: NADPH is the electron carrier used in the mitochondrial ETC. True or false?

186

Why do fats yield lots of ATP compared to carbs (high-level)?

187

Anaerobic (human) ATP per glucose is basically {{c1::2 ATP}} because only {{c2::glycolysis}} produces ATP.

188

Stage that produces most ATP in respiration:

189

Scenario: The inner mitochondrial membrane becomes very leaky to H^+. What happens to ATP production?

190

Scenario: Oxygen suddenly goes to zero. What happens first: NADH increases or NAD^+ increases?

191

Scenario: Oxygen goes to zero. What happens to lactate production (in humans)?

192

Scenario: A poison blocks ATP synthase. What happens to proton gradient and ETC speed?

186

They're more reduced -> carry more high-energy electrons.

185

False (it's mostly NADH/FADH2).

188

Electron transport chain (oxidative phosphorylation)

187

Anaerobic (human) ATP per glucose is basically 2 ATP because only glycolysis produces ATP.

190

NADH increases.

189

It drops a lot (gradient collapses).

192

Gradient builds up; ETC slows down.

191

It increases.

193

Scenario: A poison blocks Complex IV. What happens to oxygen consumption?

194

Scenario: If glycolysis is the only working pathway (no mitochondria), what is the max ATP per glucose?

195

Scenario: A cell has plenty of oxygen but no glucose. Can it still make ATP?

196

Scenario: A runner suddenly stops sprinting and keeps breathing hard. Why? (metabolism angle)

197

Scenario: A question says 'a lot of CO_2 is produced' - which stages should you think of first?

198

Scenario: A question says 'a lot of water is produced' - which stage is that pointing to?

199

Trap-check: Which comes first in the pathway: NADH production or ATP synthase action?

200

Scenario: If you massively increase ADP in a cell, respiration rate tends to...

194

2 ATP net.

193

It drops to near zero.

196

To restore oxygen and clear lactate / regenerate normal aerobic metabolism.

195

Yes, by oxidizing other fuels (like fats/amino acids).

198

ETC (oxygen becomes water).

197

Pyruvate oxidation and Krebs cycle.

200

Increase.

199

NADH production comes first.

201

Scenario: A cell has high ATP and high NADH. Does it want to run glycolysis/Krebs fast or slow?

202

How many times does glycolysis run per glucose?

203

How many times does pyruvate oxidation run per glucose?

204

How many times does the Krebs cycle run per glucose?

205

Where is NADH produced in respiration? (big stages)

206

Where is FADH2 mainly produced in basic glucose respiration?

207

Trap: glycolysis produces FADH2. True or false?

208

Fast location drill: glycolysis / link / Krebs / ETC

202

Once.

201

Slow.

204

Twice (because 2 acetyl-CoA enter).

203

Twice (because you have 2 pyruvate).

206

Krebs cycle.

205

Glycolysis, pyruvate oxidation, and Krebs cycle.

208

Cytosol / matrix / matrix / inner membrane.

207

False.

209

In mitochondria, H^+ is pumped into the {{c1::intermembrane space}} and flows back into the {{c2::matrix}} through ATP synthase.

210

Oxygen is the final electron acceptor in the {{c1::ETC}} and becomes {{c2::water}}.

211

Cycle that produces 3 NADH, 1 FADH2, 1 GTP per acetyl-CoA:

210

Oxygen is the final electron acceptor in the ETC and becomes water.

209

In mitochondria, H^+ is pumped into the intermembrane space and flows back into the matrix through ATP synthase.

211

Krebs (citric acid) cycle