- ENERGY & RESPIRATION -

CHP 12

ENERGY

- → All living things require continuous transfer of energy
- → living things
  - autotrophs - inorganic C
  - heterotrophs - organic C
- → needed for :
  - metabolism (catabolism + anabolism) (break / form)
  - Active transport
  - mechanical work
  - maintenance of 'warm' body temp

ADENOSINE TRIPHOSPHATE (ATP)

- → so energy liberation is in small bursts
- → universal intermediary molecule between energy-yielding and energy-requiring reactions
  - ↳ ∴ energy currency
- → highly suitable ∵ - readily hydrolysed
  - - small & H_2O soluble ∴ easily transported
- → reacts w/ metabolites → phosphorylated intermediates ∴ more reactive
- → ATP SYNTHESIS
- → two ways
  - reorganising chemical bonds
    - eg. glycolysis, Krebs cycle
  - using electrical potential energy
    - H^+ flow down conc grad. through ATP synthase.
    - chemiosmosis.

ATP synthase:
- has 3 binding sites
- rotates when H pass
- 3 phases :
  - ↳ binding to ADP + P_i
  - ↳ form ATP
  - ↳ release ATP

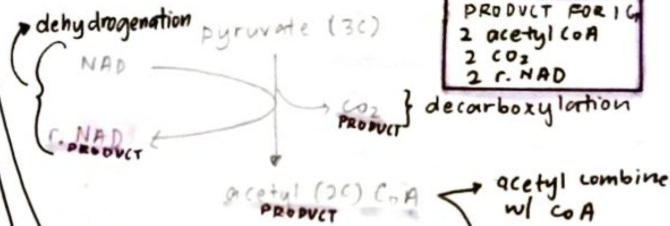
RESPIRATION

- → process in which organic molecules act as fuel
- → 4 stages of glucose breakdown :

GLYCOLYSIS → LINK REACTION → KREBS CYCLE → OXIDATIVE PHOSPHORYLATION

LINK REACTION

- → pyruvate enters mitochondrial matrix by active transport.
- → pyruvate → acetyl coenzyme A
  - → occurs in matrix
  - → oxygen ×
- → 2C can be removed from fatty acids + CoA → acetyl CoA
- → C-H chains of amino acid → acetyl coA



PRODUCT FOR 1G
2 acetyl CoA
2 CO_2
2 r. NAD

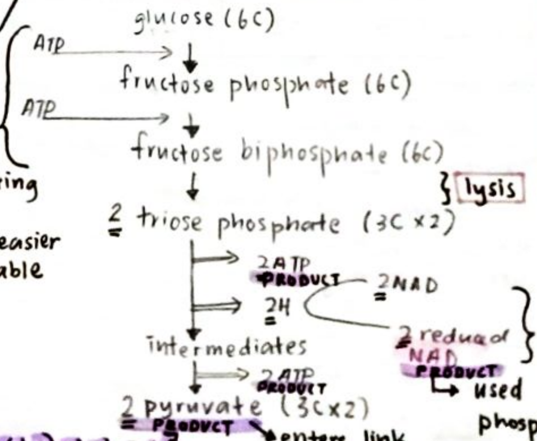
acetyl (2C) CoA
PRODUCT

- → x2 for each glucose molecule.

acetyl combined w/ CoA
↳ CoA ⇒ carrier of acetyl groups to Krebs
enters Krebs cycle.

GLYCOLYSIS

- → lysis of glucose
- → Glucose (6C) → 2 pyruvate (3C)
- → -2ATP + 4ATP → +2ATP (net gain)
- → occurs in cytoplasm
- → oxygen not needed



→ phosphorylating glucose
- so reaction easier
∵ glucose stable

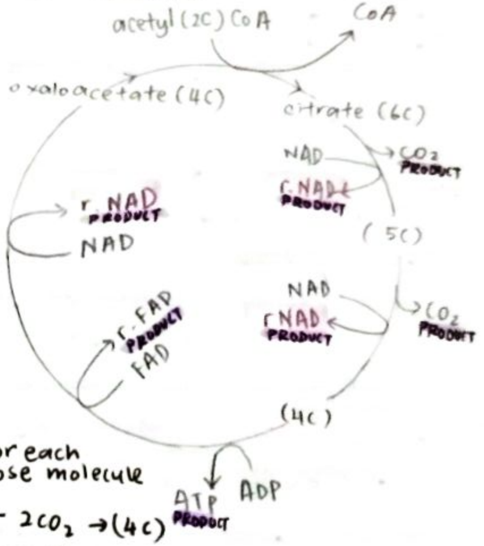
oxidation (remove H)
↳ used in oxidative phosphorylation

enters link reaction (too complex to enter krebs cycle)

PRODUCT FOR EACH GLUCOSE MOLECULE :
2 pyruvate (3C)
2 r. NAD
2 ATP

KREBS CYCLE

- → acetyl CoA (2C) + oxaloacetate (4C) → citrate (6C)
- → closed pathway of enzyme controlled reactions.



- → x2 for each glucose molecule
- → (6C) - $2CO_2$ → (4C)
- → releases H to be used in oxidative phosphorylation to provide energy.
- → oxygen×

PRODUCT FOR 1G
4 CO_2
6 r NAD, 2 r FAD
2 ATP

Glycolysis (Link - Krebs / Link - krebs) Oxidative phosphorylation

TOTAL FOR GLYCOLYSIS, LINK & KREBS
↳ 10 r NAD
↳ 2 r. FAD
↳ 4 ATP

-ENERGY & RESPIRATION-

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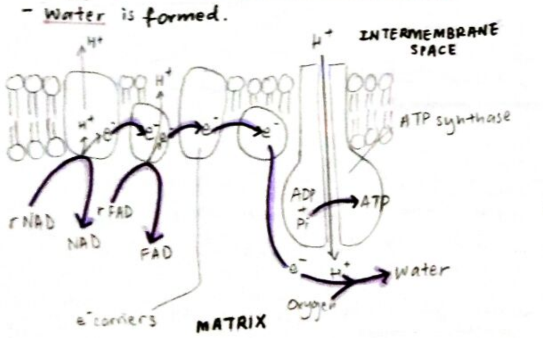
OXIDATIVE PHOSPHORYLATION

- → occurs in inner mitochondrial membrane
- → energy for phosphorylation of ADP to ATP comes from activity of electron transport chain.
- → PROCESS:
  - r. NAD & r. FAD are passed along a series of carriers in electron transport chain.
  - r. NAD & r. FAD release H which then splits into H^+ and e^-.
  - e^- flow down electron transport chain.
  - e^- moves from carrier at higher energy level to lower energy level, energy released.
  - Some energy used to move protons from matrix into intermembrane space, setting up proton gradient.
  - H^+ moves down conc. gradient through ATP synthase. (inner membrane impermeable to ions)
  - As H^+ pass through ATP synthase, electrical potential energy is used to synthesise ATP ($ADP + P_i \rightarrow ATP$), called chemiosmosis.
  - oxygen is the final electron acceptor.
  - water is formed.



MITOCHONDRIA

- → outer membrane
  - smooth & relatively permeable
- → inner membrane
  - folded inwards → cristae
  - less permeable
  - studded w/ ATP synthase
- → matrix
  - link & Krebs site
  - 70s ribosomes
  - contains enzymes
  - site of formation of ATP
- → intermembrane space pH ↓ ∵ of H^+ released.
- → Energy for ATP production is from proton gradient.

PRODUCTS SUMMARY

	CO_2	ATP USED	ATP MADE	rNAD	rFAD	NET ATP
GLYCO.	0	-2	+4	2	0	+2
LINK	2	0	0	2	0	0
KREBS	4	0	+2	6	2	+2
OXI PHOSPHO	0	0	(2.5x10) + (1.5x2) = 28	-	-	+28
TOTAL	6	-2	34	10	2	32

→ theroretically

$3 \times 10 = 30$
$2 \times 2 = 4$ } 34
∴ 38

one glucose molecule

Theoretically:

r. NAD → 3 ATP
r. FAD → 2 ATP

BUT energy used to transport ADP into mitochondria & ATP into cytoplasm ↓

Realistically:

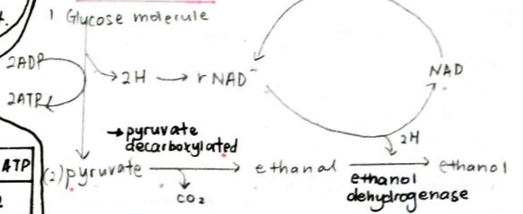
r. NAD → 2.5 ATP
r. FAD → 1.5 ATP

ANAEROBIC RESPIRATION

- → when no O_2 present, H not disposed by combination w/ O_2.
- → ETC stops working, ATP not formed by oxi. phos.
- → To produce 2 ATP from glycolysis, must pass on H from r. NAD.
- → Alternate H acceptor → pyruvate → lactate / → ethanol
- → products toxic ∴ cannot continue indefinitely

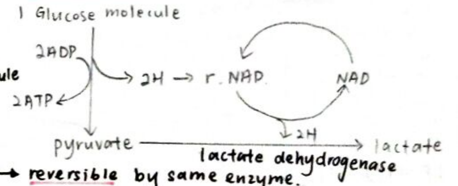
ALCOHOLIC FERMENTATION

- → H from r. NAD passed to ethanal.
- → releases NAD & allows glycolysis to continue
- → not reversible ∴ chemical PE of ethanol wasted



LACTIC FERMENTATION

- → occurs in cytoplasm
- → pyruvate acts as H acceptor & converted to lactate by lactate dehydrogenase.



- → reversible by same enzyme.
- → lactate carried by plasma to liver, converted back to pyruvate
- → liver oxidises 20% of lactate to CO_2 & H_2O when O_2 available
- → remainder convert to glycogen in liver.

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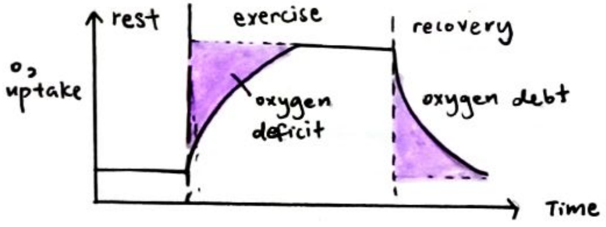
OXYGEN UPTAKE

- at rest, oxygen absorbed at 0.2 $dm^3 min^{-1}$
- during exercise, increases to 2.5 $dm^3 min^{-1}$
  - takes 4 mins for heart & lungs to meet this demand ∴ lactic fermentation occurs in muscle
    - ↳ builds up oxygen deficit
- next few mins enough O_2 supplied.
- when exercise stop, continues to breathe deeply & absorb O_2 at higher rate
  - ↳ paying back oxygen debt
- oxygen needed for:
  - ↳ convert lactate to glycogen in liver
  - ↳ reoxygenation of Hb
  - ↳ high metabolic rate ∵ organs operating above resting levels.



RESPIRATORY SUBSTRATES

- glucose is essential respiratory substrates for
  - → neurones in brain
  - → RBC
  - → lymphocytes
- other cells can oxidise lipids & amino acids.
- H per molecule ↑, energy ↑
- most of energy liberated in respiration is from oxidation of H → H_2O (H ↑ , $ADP + P_i \rightarrow ATP$ ↑)
  - ∵ H must pass through ATP synthase
- ∴ Lipids H ↑ than carbohydrates & proteins.
  - (protein density ↑ than carbs)
- energy value determined by calorimeter.

RESPIRATORY QUOTIENT (RQ)

- ratio of CO_2 to O_2 → $\frac{CO_2}{O_2}$ ← mole/volume
- shows what substrate being used
- shows aerobic / anaerobic
- if anaerobic, $O_2 = 0$ ∴ $RQ = \infty$
  - ↳ in reality, some respiration in yeast will be aerobic so $RQ < \infty$.
  - ↳ RQ ↑ ∴ alcoholic fermentation
- RQ cannot be calculated for lactic fermentation ∵ no CO_2 produced.

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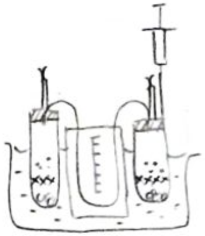
RESPIROMETER

- rate of respiration = demand for energy (O_2 uptake / unit time)
- respirometer detects change in pressure/vol of gas.
- Eg. investigate how temp affects respiration.
  - → temp & pressure alter vol of gas ∴ use thermostatically controlled H_2O bath & control tube (compensates for change in atmospheric pressure.



- → measure O_2 consumption @ particular temp x
- → repeat w/out CO_2 absorber y
- → $CO_2 > O_2$, scale show ↑ (fluild move ↓) ①
- → $CO_2 < O_2$, " ↓ (" ↑) ②
- → $RQ = \underset{①}{\frac{x+y}{x}}$ or $\underset{②}{\frac{x-y}{x}}$
- → any change in pressure / temp affects respirometer & thermobarometer tube equally
- can also use DCPIP
  - → when reduced, blue → colourless.
- syringe adjusted to make manometer level, vol of O_2 read off syringe

ADAPTATIONS OF RICE

- rice stem cortex have loosely packed aerenchyma cells
  - ↳ allows diffision of O_2 to submerged parts
- underwater leaves have ridges to trap O_2
- submerged roots use alcoholic fermentation but roots can tolerate ↑ levels of ethanol
  - ↳ produce more alcohol dehydrogenase
  - ↳ ethanol also stimulates gibberellin, which stimulates cell division
- rice grow taller so leaves & flowers above water.