Chap# 12

Energy and Respiration

1) Outline the need of energy in Living Organism:

=> ATP as Universal energy currency

=> Light energy needed for photosynthesis.

=> ATP used for the conversion of GP to TP and to regenerate RuBP

=> Energy needed for anabolic reactions

=> Protein Synthesis

=> DNA replication

=> Activation energy; activate ~~glu~~ glucose in glycolysis

=> Active transport, eg. ~~Na~~ sodium/Potassium pump

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⇒ Movement

⇒ exocytosis or endocytosis (Bulk Transport)

⇒ Temperature regulation

Features of ATP, making it suitable as the universal energy currency.

⇒ Nucleotide

⇒ made of Adenine + ~~three~~ ribose + three phosphates.

⇒ Loss of phosphate Leads to Energy release (hydrolysis releases 30.5 kJ mol^{-1})

$$ADP + P_i \rightleftharpoons ATP$$

⇒ Small and water soluble.

⇒ High turn over

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=) Used by cells as intermediate energy donor

=) Link ~~be~~ between energy yield and energy requiring reactions,
(use in active transport and ~~moste~~ muscle contraction)

ATP is synthesised by : (Glycolysis & Krebs Cycle)

- Transfer of phosphate in substrate - linked reaction
- Chemiosmosis in membrane of mitochondria and chloroplast (Oxidative Phosphory

Explain the relative energy values of ~~Carbohyda~~ Carbohydrate, lipids and proteins as respiratory substrate :

⇒ energy: Lipid > Protein > carbohydrate
39.4 17.0 15.8 kJg^{-1}

⇒ Different substrates have different No. of hydrogens

⇒ Lipid has relatively more H or C-H than carbohydrate and protein.

⇒ CH bonds located in the fatty acids of lipids

⇒ Breakdown of substrate provides hydrogen atoms.

=) For the reduction of NAD and FAD

=) Reduced NAD/FAD provides Hydrogen to ETC.

=) Hydrogen dissociates into protons and electrons

=) produce ATP by chemiosmosis

=) Lipid ~~has~~ provides more ATP per gram.

RQ: ratio of the No. of molecules of CO_2 produced to the No. of molecules of O_2 taken in as a result of ~~respira~~ respiration.

RQ	Respiratory substrate
1.0	carbohydrate
0.7	Lipid
0.9	protein

Explain why RQ value is ~~usual~~ usually between 0.7 and 1.0 in human!

=) Respire aerobically

=) mixture of substrate (example)

=) Different tissues respire different substrate

When respiration is ~~anaero~~ anaerobic, (no O

RQ value becomes infinity

~~Investigation (1)~~

Respirometer:

Coenzymes : * Coenzyme A

* NAD/FAD

Respiration

1) Glycolysis occurs in cytoplasm

2) Link reaction occurs in mitochondrial matrix

3) Krebs cycle occurs in " "

4) Oxidative Phosphorylation in the inner membrane of mitochondria

☆ Outline glycolysis :

⇒ Glucose is phosphorylated by ATP

⇒ ATP raises the chemical potential energy of glucose

⇒ Glucose is less reactive and so ATP provides activation energy.

⇒ Then subsequent splitting ~~of~~ fructose 1,6- biphosphate into two Triose phosphate molecule.

⇒ Dehydrogenation

⇒ 2 NAD reduced formed

⇒ 4 ATP produced (2 net ATP)

⇒ ~~pur~~ pyruvate produced (from each TP)

2ATP + Glucose Phosporylated by ATP

↓

Fructose 1,6 biphosphate (6C)

↓

2 × triose phosphate (3C)

NAD → reduced NAD

→ 2ATP

↓

Pyruvate

Link - Reaction :

=) When Oxygen is available, Pyruvate enters mitochondria to ~~pak~~ part in the link reaction

=) Pyruvate enters mitochondrial matrix

=) where Link reaction occurs.

=) Pyruvate is decarboxylated so CO_2 is removed.

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⇒ and ~~to~~ dehydrogenated (transfer to NAD to form more reduced NAD)

⇒ Remaining molecule combines with coenzyme A to make acetyl- CoA which starts krebs cycle.

reduced NAD ; CO_2 ; acetyl - COA

$$\text{Pyruvate} \xrightarrow[\text{NAD} \rightarrow \text{reduced NAD}]{CO_2} \text{acetyl- CoA (2C)}$$

Krebs cycle

⇒ Oxaloacetate (4C) accepts acetyl group from acetyl CoA.

⇒ to form citrate.

⇒ 4C ⟶ 6C

⇒ Decarboxylation occurs (CO_2 released)

⇒ Dehydrogenated.

⇒ more reduced NAD/FAD produced.

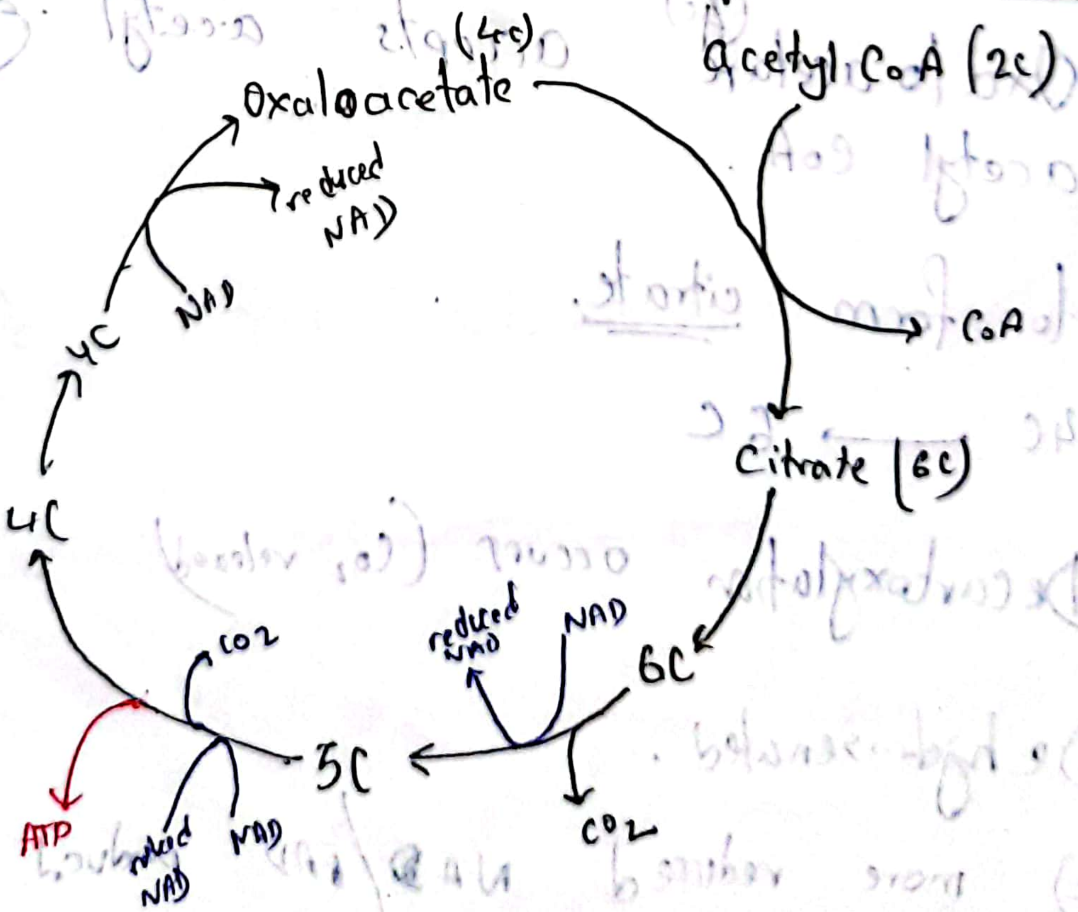
⇒ ATP formed
⇒ by Substrate-linked phosphorylation.

⇒ Citrate converted to 5C then 4C

⇒ Many 4C intermediate compounds are made.

⇒ Finally oxaloacetate is regenerated
⇒ Each reaction is enzyme-controlled.

⇒ occur in mitochondrial matrix



Role of NAD:

⇒ It is coenzyme for dehydrogenase enzyme.

⇒ reduced by accepting e^-

⇒ carrier of H^+ and e^- from krebs cycle and glycolysis to ETC

⇒ ATP produced by chemiosmosis.
transfer hydrogen to carriers in the inner mitochondrial membrane.

Oxidative Phosphorylation

⇒ reduced NAD/FAD
⇒ passed to ETC at the inner membrane.
⇒ Hydrogen released from reduced NAD
⇒ splits into electrons and protons
⇒ protons in matrix
⇒ Electrons pass ~~along~~ along chain of carriers/ ETC.
⇒ energy released
⇒ protons pumped into intermembrane space.
⇒ proton gradient formed, so it pass through the protein channels by facilitated diffusion.

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⇒ Through ATP synthase, providing energy for ATP synthesis

7) ATP produced by chemiosmosis.

⇒ electron transferred to oxygen

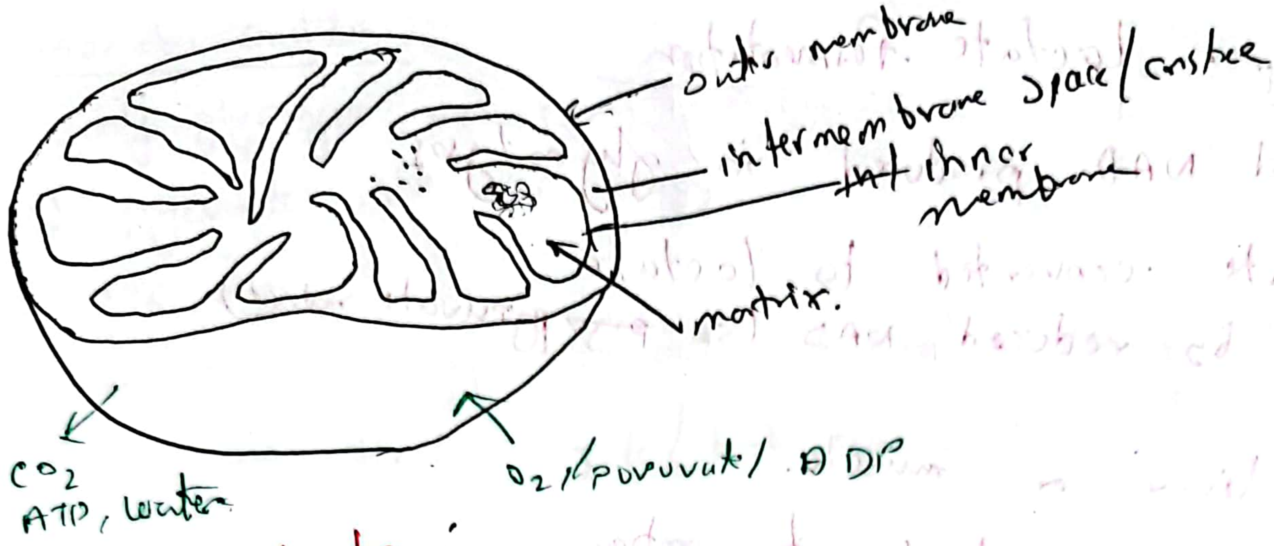
$$O_2 + e^- \longrightarrow O_2^-$$

⇒ addition of proton to ~~x~~ oxygen to form water.

$$O_2^{2-} + 2H^+ \longrightarrow H_2O$$

~~Oxygen~~ oxygen acts as a final electron acceptor to form H_2O.

Structure and function of mitochondria	
⇒ Double membrane ⇒ folded or ~~A~~ cristae (inner membrane) ⇒ increased surface area ⇒ has ATP synthase ⇒ has carrier proteins ⇒ site of oxidative phosphorylation	⇒ accept proton from ETC ⇒ protons move from intermembrane space to matrix 2) ATP synthesis
Intermembrane space ⇒ low pH due to high concen. of H^+	Matrix: ⇒ has enzyme (Dehydrogenase enz) ⇒ DNA synthesis protein (Describe) ⇒ circular DNA, 70S ribosomes Outer membrane presence of carriers for pyruvate and reduced NAD.



Anerobic respiration:

Yeast cell: ethanol fermentation (Plant):

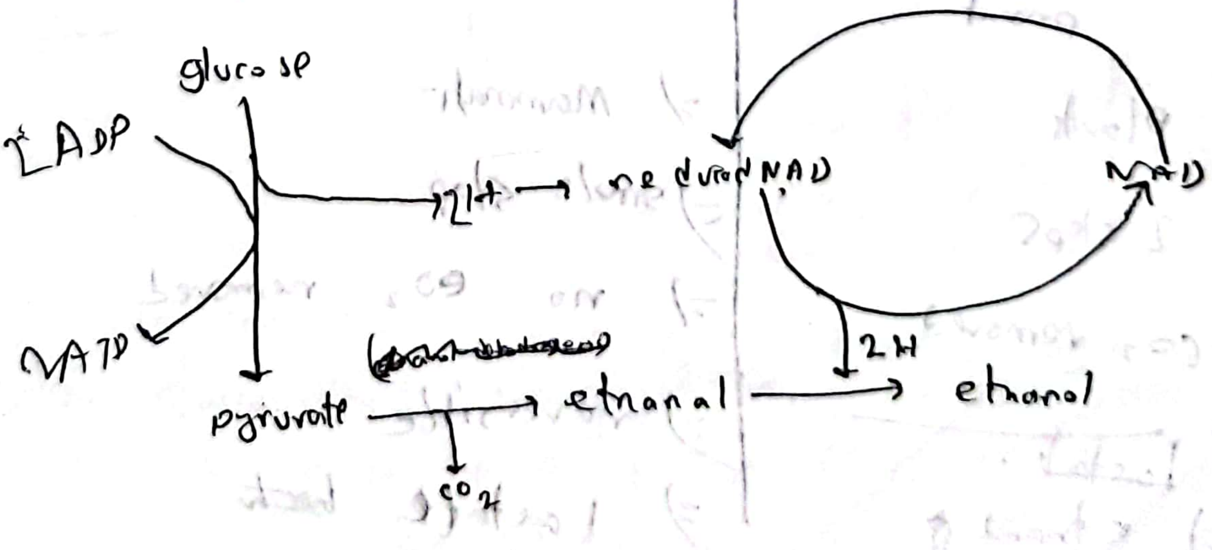
=) reduced NAD produced in glycolysis

=) Small amount of ATP produced in glycolysis

=) Pyruvate is converted to ethanal ~~by ethanol deh dehydrogenase~~ with the removal of CO_2

=) ethanal reduced by: reduced NAD, ethanol formed

=) NAD regenerated, allow glycolysis to continue



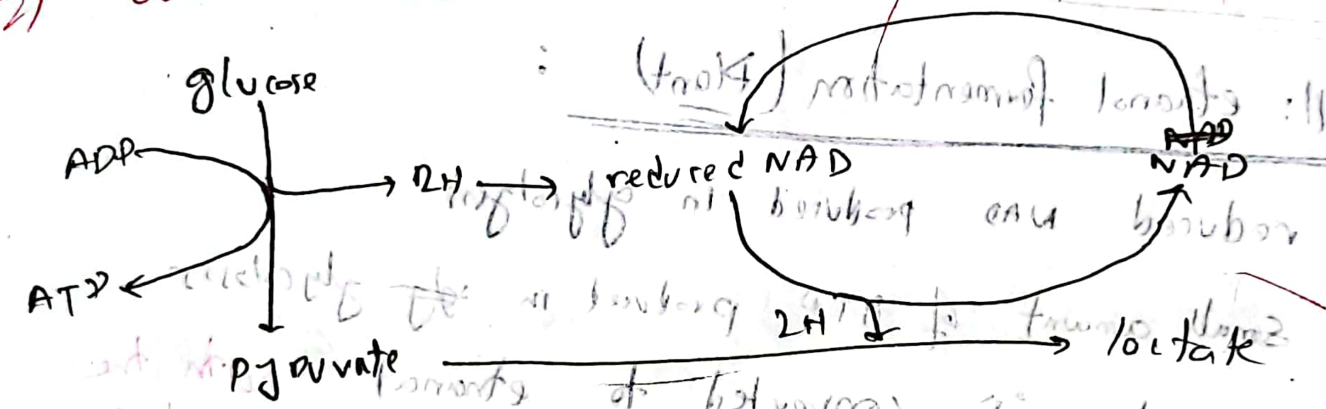
Mammals : Lactate fermentation

=> reduced NAD produced in glycolysis

=> pyruvate converted to lactate by reduced NAD (so ~~pyr~~ pyruvate reduced)

=> in liver or muscle.

=> allows glycolysis to continue.



vs

ethanol fermentation	Lactate fermentation
=> occurs when no O_2 present	=> ~~occurs when~~ same
=> plants	=> mammals
=> 2 steps	=> single step
=> CO_2 removed	=> no CO_2 removed
=> ~~lactate~~.	=> reversible
=> ethanol dehydrogenase	=> lactate ~~dehydro~~ dehydrogenase

In anaerobic condition

=) only glycolysis occurs, produces net 2 molecules of ATP. only by substrate-linked reaction
=) pyruvate still has energy
=) ETC stops
=) because no oxygen to act as final electron acceptor
=) so no krebs cycle / link reaction / OP / chemiosmosis

Adaption for rice in aerobic & anaerobic respiration:

~~=) when~~ Most plants cannot grow in deep water. as the roots do not get enough O_2 for aerobic respiration,
Nor, if the leaves are ~~sub~~ submerged, can photosynthesis take place, bcz CO_2 is not enough available, as gases ~~con diss~~ diffuse slowly in water.

=) So the rice ~~&~~ shows an increased rate of upward growth away from the waterline.
=) ~~Rice~~ Rice ~~has~~ plants have aerenchyma tissue in the stems and roots
↳ allow gases that enter the stomata to diffuse to other part of plant (above and below water)

=) When there isn't enough ~~x~~ O_2, plant continue of anaerobic respiration to produce ATP. by ethanol fermentation

→ Rice plants can tolerate higher levels of toxic ethanol than other plants

They produce more ethanol dehydrogenase

↳ breaks down ethanol.

=> Rice have aerenchyma

=> in stem and roots

=> ~~held~~ help oxygen to diffuse to roots

↳ (low O_2 concen. in water)

=> Shallow roots

=> air film trapped on underwater leaves

=> modified growth regulated by gibberelin

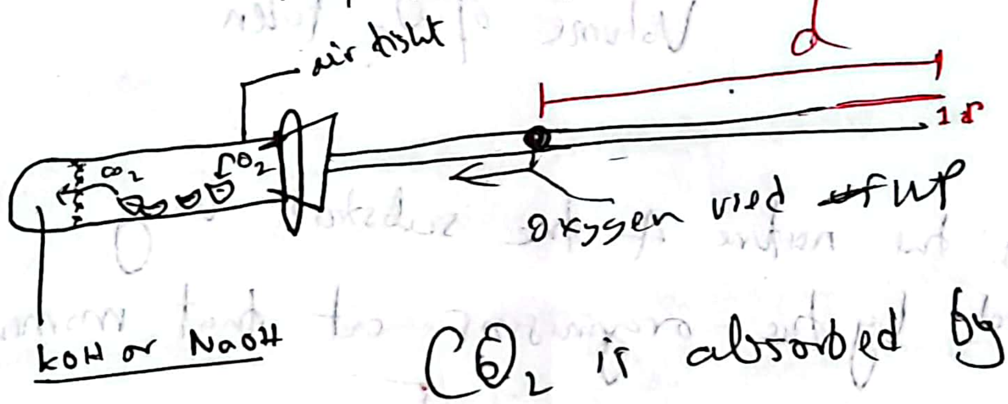
=> anaerobic respiration underwater produce ethanol

=> tolerant to high ethanol concentration.

=> ethanol dehydrogenase

Investigation 1

Respirometer: ~~Device~~ used to measure rate of respiration of a living organisms.



CO_2 is absorbed by NaOH

Volume of O_2 taken up = $d\pi r^2$

$$\boxed{\text{rate of respiration} = \frac{\text{Volume of } O_2}{\text{time}}}$$

When temperature increased, ~~rate of~~ ⇒ reaction becomes more faster

⇒ as KE of molecules increased

⇒ so more frequent collision

⇒ so respiration occurs at faster rate.

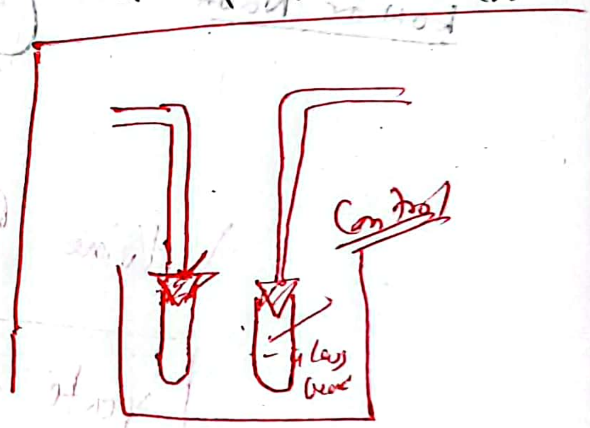
⇒ more ESC

Determining RQ :

$$RQ = \frac{\text{Volume of } CO_2 \text{ produced}}{\text{Volume of } O_2 \text{ taken}}$$

~~reveals~~ reveals the nature of the substrate being respired by the organisms at that moment

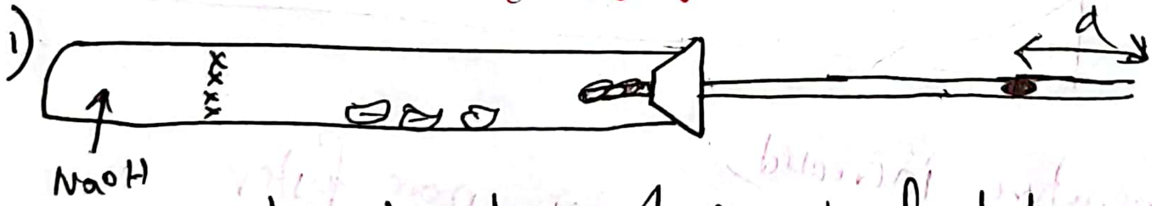
RQ	Substrate
1	Carbohydrate
0.7	Lipid
0.9	protein



Temperature should constant and pressure to

CO_2 absorbed

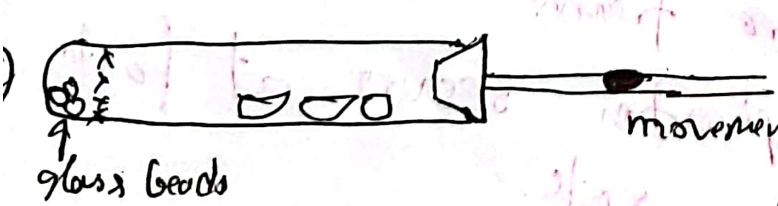
1)



⇒ Find volume of O_2 in fixed time

⇒ Repeat to several ~~mes~~ measurements and take to mean

2)



movement is due to both O_2 used and CO_2 produced

~~Volume~~

repeat

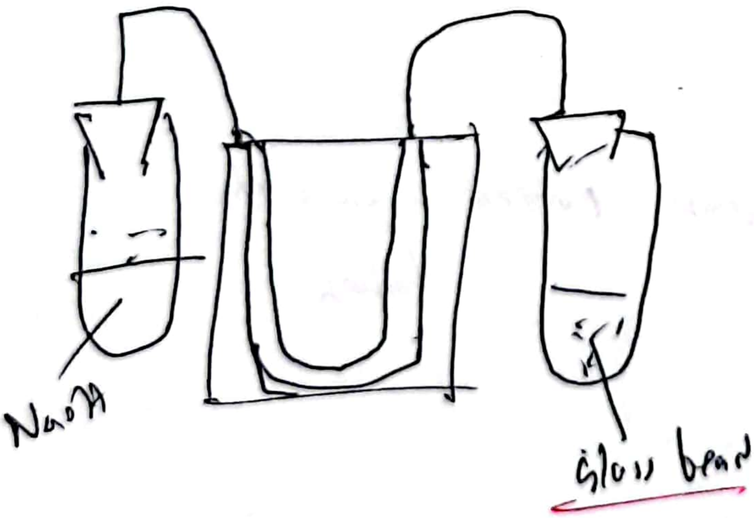
Volume of CO_2 produced = ~~dif~~ volume in test 2 − volume in test 1

Redox indicator

- DCPIP is a blue redox indicator ~~when~~ which becomes colourless when ~~re~~ reduced.
- ~~more~~ faster rate, ~~faster~~ more hydrogen released, so more faster dyes are reduced.

Control:
- Volume of dye added
- Volume of yeast ~~su~~ suspension
- Type of substrate
- Temperature.

- RQ of carbohydrate = 1.0
- " " protein = 0.9
- " " lipid = 0.7



- act as control
- control eliminates effects of variables other than the independent variable

Describe and carry out investigations using redox indicator, DCPIP, to determine the effect of substrate concen. ~~of~~ on the rate of respiration of yeast.

=) Vary the substrate concen. such as glucose.

=) control : volume of yeast ; volume of glucose ; indicator ; temperature between (20 - 4K)

=) oil layer to exclude air

=) indicator ~~be~~ turns from blue to colourless

=) due to H^+ ions from respiration

=) time how long ~~to~~ it takes for colour change

=) repeat experiment

=) ~~calc~~ calculate mean

=) graph with glucose concen. and time taken