GASEOUSEXCHANGE INANIMALS

Themajorityofanimals needoxygeninordertooxidize theorganicmaterials andproduce energyforcellularactivities.

The oxidation of the food not only yields energy but also carbon dioxide which must be constantly removed from thebody.

Theprocessofmovingoxygenintothebodyandcarbondioxideoutofthebodyiscalled breathinginorventilation.**Gaseousexchange**involvesthe passageofcarbondioxide througha respiratory surface.Diffusionisthemaintransportprocess involvedingaseous exchange.

Characteristicsof therespiratory surfaces

1. Theyhavealargesurfaceareain order toincreasetherateof diffusion
2. Theyare usuallythinandpermeablein order toreducetheresistancetodiffusion
3. Theyaremoist todissolvethegases
4. Theyarewellsupplied withblood.

Typesof respiratory surfaces inanimals

Smallanimalssuchasamoeba usetheirentirebodysurfaceforgaseous exchange.Theyhavea highsurface area /volumeratio.Asorganismsincreaseinsize,thesurfacearea/volumeratio decreases,hence there is needtohavespecialrespiratory systemororgans.

Gaseousexchangeinloweranimals

Protozoa andanimalswithrelativelyfewcellslikethecoelenterates andwormsdon’tbreathe.They relyondiffusiona loneforexchangeof gaseousbetweentheirbodiesandtheliquidenvironmentin whichtheylive.

Earth worms thatliveinsoil havegaseous exchangestakingplaceintheskinwhichisthinand moistand has agoodbloodsupply.

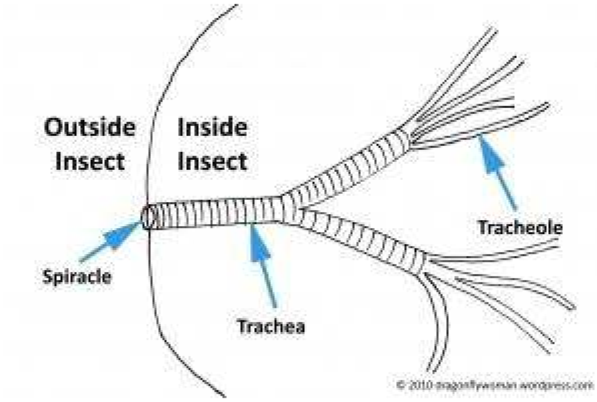
Gaseousexchange ininsects

Therespiratorysystemconsistsofa networkoftubes formingthe trachealsystem.The tubes opento theoutside through pores calledspiracles locatedonthesides of thethorax and the abdomen. The tubes calledthetrachea arelinedwithcuticleandhave spiralrings whichprevent the walls fromcollapsinginwards.

Thetracheais dividedintosmaller tubescalledtracheoleswhicharecloselyassociatedwiththe tissues.Some insects haveairsacsconnected to the trachea.Theseairsacscanbeinflatedor deflatedin order tofacilitategaseous exchange

Ventilationis broughtaboutby thecontraction andrelaxationoftheabdominalmuscles.In locusts,airisdrawnintothebodythrough the thoracicspiraclesandexpelled throughthe abdominalspiracles.

Diagram



GASEOUS EXCHANGEINAMPHIBIANS

Amphibianslive intwoenvironmentsairand waterandare thereforeadapted togaseous exchangeinlandand inwaterhenceareadaptedfor gaseousexchangein water andonland. Also showchangeof respiratorysurfacesandorgans as theydevelopfromgillsin tadpolestolungs, skinand mouth cavityin adults.

Youngtadpoleshaveexternal gills andoldertadpoleshaveinternal gills thatworkinasimilarwayto thoseoffish.

Adultamphibiansuse.

1.**Skin.**

Theskinsurfaceis always keptmoistbysecretions frommucus glands so thatoxygen fromthe atmospherecandissolveinto themoisture anddiffuses easilyintotheskin. Alsotheskin iswellsupplied with bloodvessels so thatoxygen easilydiffusesintothe bloodandcarbondioxide out. Alsothe skin is thintoprovideashortdiffusiondistancenecessaryfor fastgas diffusion. Amphibians usetheskinfor gaseousexchangebothonlandandin water.

2. Lining of thebuccalcavity

Theliningofthemouth cavity (buccal)isonlyused when theamphibianisonland. Theamphibiancloses its mouth andglottis and opens itsnostrils.Itthen lowersthe floorofthebuccal cavity,volumeinthe buccal cavityincreases andthereforepressuredecreasesandair isforced into themouthcavityvia the nostrils.Theliningofthebuccal cavityisthin,moist andwellsuppliedwith bloodvessels. Oxygen is diffusingintothebloodandcarbondioxidediffuses out.

3.Lungs

Lungs arenotused ingaseous exchangeveryfrequentlybutwhen theyare,airisfirsttakenintothe mouth cavitywhichislowered.Thenostrilsarethen closed andthe floorofthebuccal cavityraises whichforcesairintothelungs. Oxygen diffusesintothebloodcapillariesofthelungs ascarbondioxide diffuses out.

GASEOUS EXCHANGEINFISH.

Infishthemediumof exchangeis water.Therespiratoryorgans areininternal gills thatextractoxygen from thewaterandexpelcarbondioxideintoit

Inhalationinfish

Thefloorofthemouth is lowered,increasingthevolumeofthemouth (buccalcavity),hencedecreasing the pressurewith inthemouth.Operculumcloses, mouthopens andwaterenters throughthemouth intothemouthcavity.

Exhalationinfish

Mouthcloses,floorof themouth is raised hencedecreasing volumeof themouthandasa resultthe pressurewith in themouthincreases, forcingwaterto moveoverthegills andaswaterismovingover thegills,oxygen fromwater diffusesinto thegill filamentsandcarbon dioxidediffuses outof thegill filamentsintowater. Thehighpressurealsoforces theoperculumtoopen andwater flowsout.

FUNCTIONSOF EACHOFTHE PARTS

- **Gillfilament**:sitesfor gaseous exchange.
- **Gillrakes**:Thesefilterlargeparticlesof thewaterbeforetheyreachanddamagethegill filament.
- **Gillbar**: Thisprovidessupportandattachmentforthe gill filaments.

Adaptation of gillsforgaseousexchange

- Presenceof numerous gill filaments toincreasethe surface areafor gaseousexchange
- Each filament issupplied with adensenetworkof bloodcapillariesforefficient transportof gases
- Each filament isthinwalledtoreducethe distanceacrosswhichgasesdiffuse
- Thefilamentsarefurther subdivided intolamellaetoincreasethe surfaceareforgaseous exchange

Gaseousexchange inbony fish(e.g.tilapia)

Gaseousexchangein fishtakes place betweenthegills andthesurroundingwater.Thegillsare locatedin theopercularcavitycoveredby a flap ofskincalledtheoperculum.Eachgillconsists ofanumberof thinleaf likelamellaeprojectingfromaskeletalbase(brachialarch)situatedin the wallof thepharynx.

Eachgillissupported byagillbarthrough whichbloodvesselssendbranchestothefilaments.

Diagram of thegill

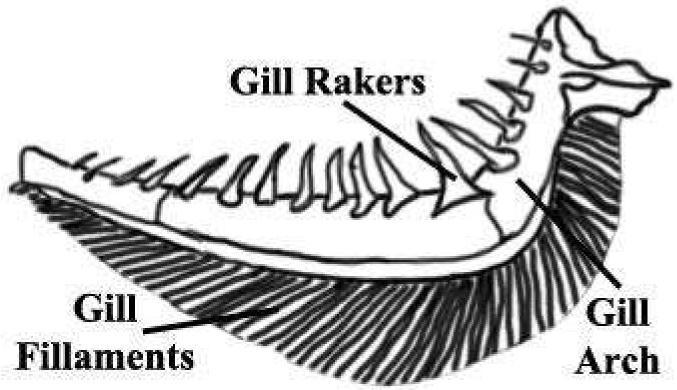
Functionsof partsofthe gill

1. Gillrakers. These filterlarge particlesinthewaterbeforetheyreachanddamage thegill filaments

2.Gill bar.Theseprovideattachment andsupport for thegillfilaments

3.Gill filaments.Thesearethesitesof gas exchange

Diagram



Ventilation

Asthemouthopens, thefloorofthemouthislowered.Pressureinside themouthislowered andthiscauseswatertobedrawnintothebuccalcavity. Meanwhilethe operculumisclosed, preventingwater fromenteringorleavingthroughtheopening.

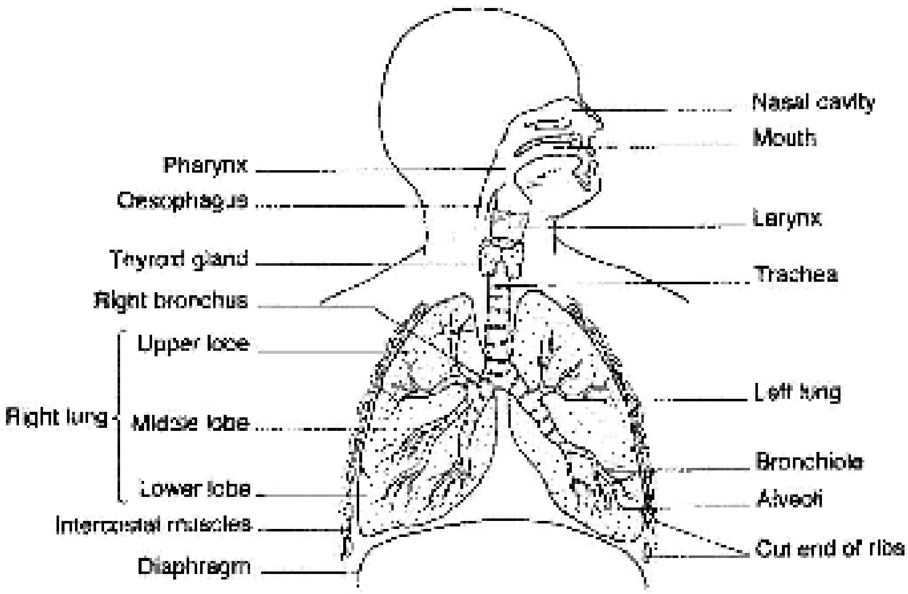
Asthemouthclosesandthefloorofthemouthisraised,pressureinthebuccalcavityincreases.

Wateris forcedover the gillsasthe operculaareforcedtoopen. Aswater passesover the gills, oxygenisabsorbedandcarbondioxidefromthegills dissolvesinthe water.

Gaseousexchange in mammalse.g.man

Thebreathingsystemofamammalconsistsofa pairoflungswhicharethinwalledelasticsacs lyinginthethoraciccavity.Thewallsofthe thoraxconsistoftheribsand theintercostal muscleswhilethe floorconsists ofthe diaphragm,amuscular flapof tissuebetweenthethorax andtheabdomen

Diag.main partsofthebreathing system in man



Airentersthelungsthroughthetracheawhichisdividedintotwobronchi,onetoeachlung. The tracheaandbronchi havewallsmade upofrings ofcartilage.Insidethelungs,eachbronchusis dividedintosmallertubescalledbronchioles.Thebronchiolesterminate insaclikeatriagiving risetonumerousairsacsoralveoli. Eachalveolusisathinwalledsac covered bynumerous blood capillaries

Ventilation

Exchangeofairbetweenthelungsandtheoutsideismadepossiblebychangesinthevolume ofthethoraciccavity.Thisvolumeisalteredby themovementsoftheintercostalmusclesand thediaphragm.

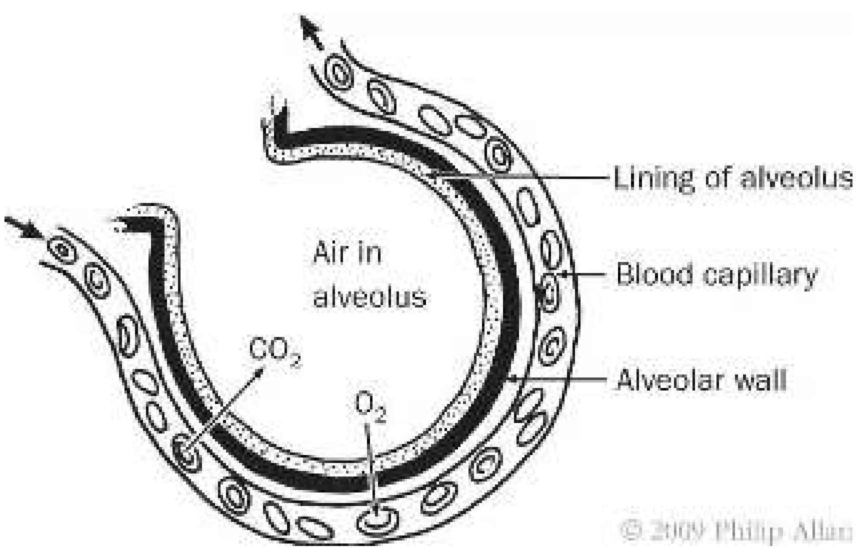
Inhalation	**Exhalation**
▪External intercostalmuscles contractandinternal intercostalmusclesrelax.	External intercostalmuscles relaxand internal intercostalmuscles contract
▪Thiscausestheribcage tomoveupwardsandout wards (theribcagerises)	This causestheribcagetomoveinwards and downwards (theribcagefalls)
▪The Diaphragmcontractsandflattensout.	The Diaphragmrelaxesandbecomesdome shaped.
▪Thevolumeofthe chestcavityincreasesasthepressure is lowered.	Thevolumeofthe chestcavitydecreasesas the pressureincreases
▪Thelungs fill with air (inflate)	Thelungs deflateor expelair.

Gaseousexchange betweenthe alveoli andthe capillaries

- Thewalls of thealveoliandthecapillariesarevery thinandclosely attachedtoeach other.Thismakesdiffusionofgasesveryefficientbecausethedistance betweenthe insideof thecapillaryandtheinsideof thealveolus isvery small.
- Furthermore,thelungshaveover700millionalveoliofferingalargesurfaceareafor gaseousexchange
- The wallsof thealveoliarealsomoist,thismakesoxygen dissolveeasily

Blood fromthetissueshasahighconcentrationofcarbon dioxideandverylittleoxygencomparedtoalveolarair.Theconcentrationgradientfavoursdiffusion ofcarbondioxideinto thealveolusandoxygenintothebloodplasmainthecapillaries.Theoxygenisthenpickedby thehemoglobinof redblood cellsandtransportedincombination withit asoxyhemoglobin. Carbondioxide whichisatahigher concentrationinthebloodisnormally carriedasbicarbonate ionsintheplasma.Thisbreaksdownandreleasescarbondioxidewhichthendiffusesintothe alveolus.

Diagram



Percentage composition of inspired and expiredair(%by volume)

Component	**Inspiredair**	**Expired air**
Oxygen	21	16
Carbondioxide	0.04	4
Nitrogen	79	79
Moisture	Variable	saturated

GASEOUS EXCHANGEINPLANTS

Thesiteof gaseousexchangeinplantsismainly thestomataontheleavesandthelenticelson herbaceousstems.A fewplantslivinginwaterhavebreathingroots too.

Duringday

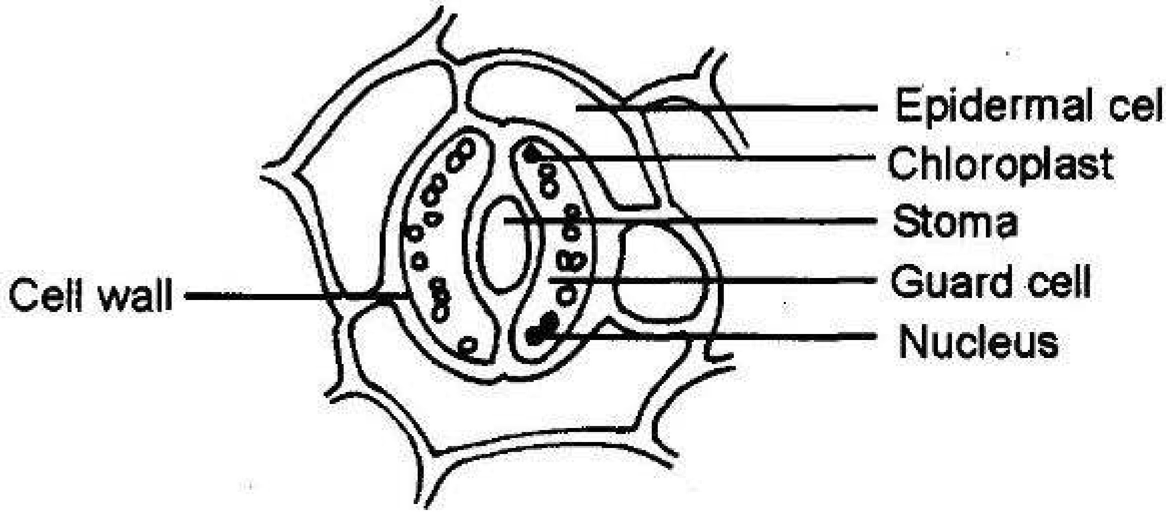
Indaylightplantsmainlyusecarbondioxidefor photosynthesisandgiveoffoxygen.However,plant cellsalsorespireduringdayhenceusing oxygenandgivingoutcarbondioxide(respiration) Photosynthesisismoreactiveprocessof thetwothereforeuses moreCO_2thanis givenoutduring respirationanditgivesoutmoreO_2thanisused upinrespiration.Plantsalsogive off H2O(g)during respiration.

Duringnight

Inthedark photosynthesisstops butrespirationcontinues. TheplantsthereforetakeinO_2fromits surroundingandgiveoutcarbondioxide. Thevol.ofgas exchanged atnightis usuallyverysmall becauseplantsaregenerallylessactiveandrespireless. Mostof its stomatatendtocloseatnight. N.B.plantsdon't breathe butgasespass intoandoutofthembysimplediffusion.Plantsdon'thavea breathing mechanismbecausetheydon'tcarryoutlocomotionthereforehavelowenergy requirements,havea lowmetabolicratesandthereforerequired less O_2don't havetokeep a constant temp.

Stomata

Aretinyporein theepidermisof foliageleaves. Eachstoma isbounded bybeanshaped guardcells. Guardcells differfromotherepidermal cells insize,shapeandin havingchloroplasts. Thewallsofguardcellsnextto theporearethickenedandinelasticareshown above.Theopeningand closingof stomata is controlled byitsguardcells.When turgor pressurein guardcellsis high,the guard cellsbecomeswollen andthestomatal poreopens.When turgor pressure islow,theguardcells become flaccid andthestomatal porecloses. Stomatagenerally tendtocloseatnightandopen duringtheday. Alsotends tocloseduringthedayifconditions areunfavorable.



MECHANISMOF OPENINGANDCLOSINGOF STOMATA.

Daytime(light)	**Nighttime(dark)**
1. TheconcentrationofCO_2islowbecause photosynthesis isgoingon.	TheconcentrationofCO_2ishighbecause photosynthesis has stopped.
2. Theacidityin theguardcells islowandthe PH ishigh.	Theacidityin theguardcells ishighandthePH is low.
3. This favour conversionofstarch tosugar.	This does favourconversionof sugartostarch.
4. H_2O then enters theguardcellsby osmosis.	Waterislostfrom theguardcells tothe surrounding.
5. the guardcellsbecome more turgid	Guardcells becomeflaccid.
6. the stomata**opens**	Thestomata**closes**

TheAverageCO_2content of theatmospherehas beenfoundtobefairlyconstantatabout0.031. 300 parts permillion(ppm).Itis possible tomeasurethe CO_2contentof airaccurately. Thegraphbelow showsmeasurements for theairof aforestovera period of24hours.

TISSUERESPIRATION(CELLULAR)

This is the oxidation or breakdown of foodsubstance (respiratory substrate)to releaseenergy.This energy released from this process is used to combine ADP with inorganic phosphate to make ATP. Thecommonfood substancesthat arerespiredarecarbohydratesintheformofglucose. Inabsenceof glucoselipids can alsobebroken down togiveenergyandin timesof emergenciese.g. duringstarvation, proteins canalso bebroken down togiveenergy.

Thereapetwo formsof tissuerespiration.

1. **Aerobicrespiration**whichis thebreakdownof thefoodsubstancetoreleaseenergyin presenceof Oxygen.
2. **Anaerobic**isthebreakdown of foodsubstance toreleaseenergyinabsenceofoxygen.

AEROBIC RESPIRATION:
Is the oxidation or breakdown of glucose to yield chemical energy ATP in the presence of oxygen.

This process is the summarized by the equation below;

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + ATP$$

NB: the process occurs in the cytoplasm of the cell and mitochondria and its divided into three stages i.e. glycolysis, Krebs cycle and electron transport system

ANAEROBICRESPIRATION

is the breakdown of glucose (sugars) in the absence of oxygen to yield chemical energy(ATP). This occurs in the cytoplasm of the cell.

INPLANTS AND FUNGI:

Yeastsareexamplesoforganismsthat leavein placeswherethereislittleor nooxygen andhavetorespire anaerobically. Theseunicellularfungi leavein sugar containingsolutionsuchas overripefruit juice. Yeastrespiresbybreakingdownsimplesugars toethanol andCO_2 andsomelittleenergyisreleased

Glucose $\longrightarrow$ **Ethanol+Carbon dioxide+Energy**

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + CO_2 + 210k(joules)$$

Theaboveprocessisknownas**fermentation**.Thealcoholiccontentofbeers, winesandspirits e.g.waragi, Brandyisethanol.Thesedrinksaremadebyallowing yeasttofermentin naturallyoccurring sugar solutions. E.g. beerfrom maltwhichcomesfromgerminated barley

Bakersuseyeasttomakebread rise.Theholes inthedoughareformed bybubbles ofCO_2given offas the yeastrespires.Thismakes breadmorespongyandeasiertodigest.

INANIMALS

Endoparasitese.g.tape worms, respiresanaerobicallyandmostanimal tissuecanrespireanaerobically if theyneedto e.g. duringan exercise muscles will useup more energysoquicklyand thus more oxygen is needed to support aerobic respiration in the person's muscle than the body can supply.For thefirstfew minutesof theexercise,themusclecells respireaerobicallyuntilthe immediatesupply of$O_2$is usedup, afterthat; theyrespireanaerobicallyby breakingdown glucosetolacticacid, thus the person builds up an oxygen deficit. When exercise stops, the person continues to breathe deeply and absorbs oxygen at higher rate than when at rest. This post exercise uptake of extra oxygen which is paying back the oxygen deficit is called **the oxygen debt**.

Glucose $\longrightarrow$ lacticacid+Energy. $C_6H_{12}O_6$

$2(C_3H_6O_3)$+150kjoules $\longrightarrow$

Thewasteproductlacticacidbuilds in themusclescells andsince itis toxic,itmustnotbeallowed to remaininthemusclesthat's whyaftera race we continueBreathingin quicklyand deeply in order to supply O_2supply needed tooxidizesthelacticacidtoenergy, CO_2 andH_2O,or convert it to glycogen.

An oxygen"debt"istheamountof oxygenrequiredtobreak downthelacticacidwhichhas accumulated intherespiring muscles toCarbondioxide, waterandenergy

Lacticacid+O_2 $\longrightarrow$ Carbon dioxide+water+Energy

$C_3H_6O_2$+ 3O2 $\longrightarrow$ $3CO_2$+ $3H_2O$+Energy

If toomuch lacticacidbuilds upin ourmusclecells onedevelops amusclecramp/fatigueifonetriesto persistthemusclesmaycoarse upandonecollapses fromexhaustion.

OBLIGATEANAEROBES:

Theyrespireentirelyanaerobicallyandtheylivepermanentlyinoxygen deficientconditions suchthat the presenceofO_2poisonsthem.

FACULTATIVEANAEROBES:

Theseanaerobescanrespireaerobicallybutinlimitedoxygen orabsenceofoxygen, theyrespire anaerobically.

EXPERIMENTS.Describetheexperimentsbelow.Useany text book

EXP'T1: Doestheanaerobic respirationof yeastproduce$CO_{2?}$ EXP'T2: Dogreenplantsproducecarbon dioxideduringrespiration EXPT'T3: Dogerminatingseeds produceheatenergy?

EXP'T4:iscarbon dioxidepresentinthe airweexhale? /Tofindoutwhetherexhaled air contains carbon dioxide

EXP'T4: iscarbondioxidepresent intheairweexhale? /Tofind outwhetherexhaledaircontains carbondioxide

Apparatusandmaterials

- Washbottles
- Deliverytubes
- Smallanimal,e.g. afrog
- Limewater
- Caustic sodasolution
- Widemouthedbottle

Procedure

Set uptheapparatusasshownbelow, Put afroginthe widemouthed bottle.

Placesome causticsodasolutionandlime water separately in thefirst two bottlesrespectively

Connect thedeliverytube frombottleD toa filterpumpfor30 minutes

Observeany changesin thebottles

Illustration NB: DRAW THE SET UP IN THE SPACE LEFT

Observation

Limewaterin washbottleB remained clearwhilethatinbottleD turnedmilky

Explanation

Thecaustic sodasolutionwas usedtoabsorbcarbondioxide fromthe air beforereachingthe animal.Thatis why thelimewaterinbottleBremainedclear.Thelimewaterinbottle Dturned milkydue to thecarbon dioxide from theanimal. Sincecarbon dioxideis oneof the productsof aerobic respirationinanimals,theorganismisthereforerespiringanaerobically.

Conclusion

Ananimalgivesoutcarbondioxide duringphotosynthesis

ComprisesbetweenAerobicandAnaerobicrespiration

Similarities.

- Bothreleaseenergy**.**
- Both takeplaceinlivingorganisms.
- Both require glucoseas arowmaterial.
- Both produceCO_2exceptin man.

Differences

Aerobic	Anaerobic
Requires O_2tobreakdownglucose	doesn’trequireO_2tobreakdown glucose
More efficient& moreenergyisproduced (38ATP molecules)	Lessefficient&lessenergyproduction(2ATP molecules)
Endproductareenergy,CO_2&H_2O inbothplants andanimals	Endproductsin plants areenergy,ethanol&CO_2 andin animalsenergyandlacticacid.
Thereis completeoxidationof glucosetoform energy,CO_2&H_2O	Incompletebreak downofglucosetointermediate compounds (lacticacidin animals and ethanol in plants)
Mostcommonoccurringinboth plants&animals	Rareoccurringin a fewplants ,fungi ,&animals
It’s a relatively permanent process	Is a temporary process
Takes place in both cytoplasm and mitochondria of cell	Takes place only in the cytoplasm of the cell

Whathappenedwhena cellrespires?

Glucoseand other simple sugars arethemostwidely used respiratorymaterialsthroughoutthe living world. Inlivingcells,theyarebrokendown instageseach controlled byits own enzyme.Ateachstage littleenergyis releasedandstored temporallyin a chemicalcalled**ATP (**Adenosinetri phosphate).**ATP** molecules consistof three phosphates groups andwhen a cellneedsenergyATPis broken to**ADP**and energyproduced.

ATP $\longrightarrow$ ADP(Adenosinedi-phosphate)+phosphate +Energy.

ATPisreformed fromADPandaphosphatesgroupasenergyisreleased inthe respirationprocess ATP providesameansofstoringenergyuntilitisrequiredandthereforearoidswastage ofenergy.When a glucoseamoleculeiscompletelyoxidizesinaerobicrespirationabout32 molecules ofATPareformed. Each providesa small storeforenergywhichof cells canreleaseanduseasrequired.

ADP (Adenosinediphosphate)+phosphate(inthepresence of energyfromrespiration)ATP

Comparisonsof respirationandphotosynthesis

Respiration	**Photosynthesis**
1. Occurs inall livingcells ofplants andanimals.	Occursonlyinplants containingthegreen pigment chlorophyll.
2. Goesonatalltimes.	Onlyoccurs inlight.
3. UsesO_2butthe process canoccur withoutthis gas.	$CO_2$is neededas arawmaterial.
4. $CO_2$is produced.	$O_2$is produced.
5. H_2O is produced	MoreH_2O is used upthanis produced. (Theyisa netgainof H_2O).
6. Energyisproduced.	Energyof sunlightisobserved bythechlorophyll andstored incomplexorganic molecules.
7. Proceedsatamuchslowerrate thanphotosynthesisingreen plants intermsof gaseousexchange.	Produced atamuch fasterratethanrespiration ingreen plantsintermsofgaseousexchange.

Obligateanaerobesarethosethatrespireanaerobicallyandarekilled byeven anO_2tracee.g. certain anaerobic bacteria.

Facilitates anaerobes have the ability of facilitate to respires anaerobically but are able respires aerobically when theopportunityarisese.g.yeast.