

牛 津

学科英语基础丛书

GCSE

生 物

through diagrams

BIOLOGY

牛津图解中学生物



W R Pickering

英汉
双语

上海教育出版社
牛津大学出版社

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(英汉双语)

W. R. Pickering

朱毅 王立非 吴文智 译

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W. R. Pickering 著

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Aerobic respiration involves the oxidation of food to release energy to perform work in living organisms.

EQUATION FOR AEROBIC RESPIRATION



Oxygen consumption can be measured using a respirometer.

Involvement of enzymes can be demonstrated by the effects of temperature on respiration.

Energy release can be measured as the production of heat.

Carbon dioxide release causes

- limewater to turn milky
- bicarbonate indicator solution to turn from red \rightarrow yellow-orange.

GLUCOSE



INTERMEDIATE COMPOUND (PYRUVIC ACID)



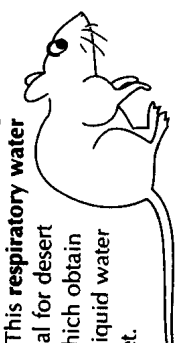
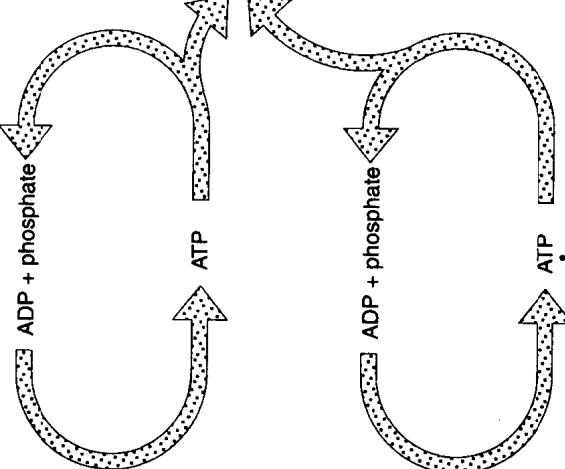
CARBON DIOXIDE AND WATER

Obtained from food by the digestion of sucrose or starch, or from storage by breakdown of glycogen.

These reactions can take place **without oxygen** but release **very little ATP** (see below).

These reactions occur in the mitochondria of cells. They take place **only if oxygen is present** but release **large amounts of ATP**.

These end-products may be excreted (carbon dioxide through the lungs, for example). This **respiratory water** may be vital for desert animals which obtain very little liquid water in their diet.


ENERGY

This energy may now be used to perform the **work** needed to keep cells and organisms alive. Much of the energy will eventually return to the environment as **heat**.

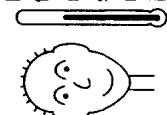
ATP (Adenosine triphosphate) is a convenient form of 'energy currency'. Its availability means that

- the energy released by respiration is trapped in convenient packets
- the energy packets can be spent (when ATP breaks down to ADP - adenosine diphosphate - and phosphate) when and where it is needed.


Growth: involves the consumption of energy for the synthesis of large molecules from smaller ones (e.g. proteins from amino acids).



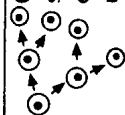
Maintenance of body temperature: all chemical reactions in the body release some heat. Reactions in liver and muscles are particularly important.




Active transport: the movement of molecules against a concentration gradient, e.g. ion uptake by roots.



Cell division: replication and separation of chromosomes is very energy demanding. A human replaces billions of cells every day.

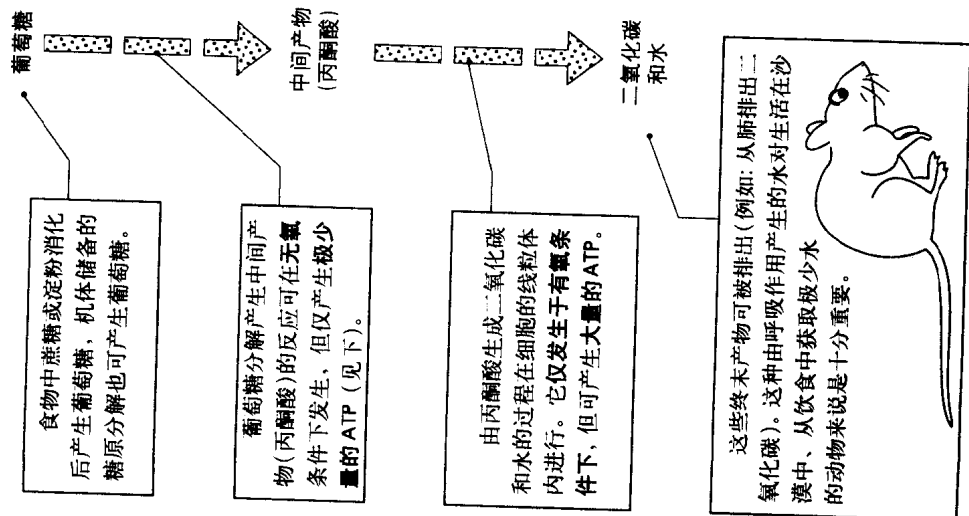


Movement: contraction of muscle requires energy. The supply of energy will run out if food or oxygen is limited.

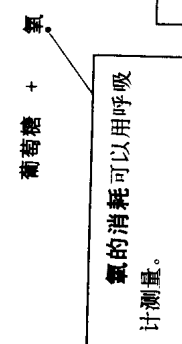


需氧呼吸作用

生物利用食物氧化释放的能量来进行生命活动。



需氧呼吸的方程式

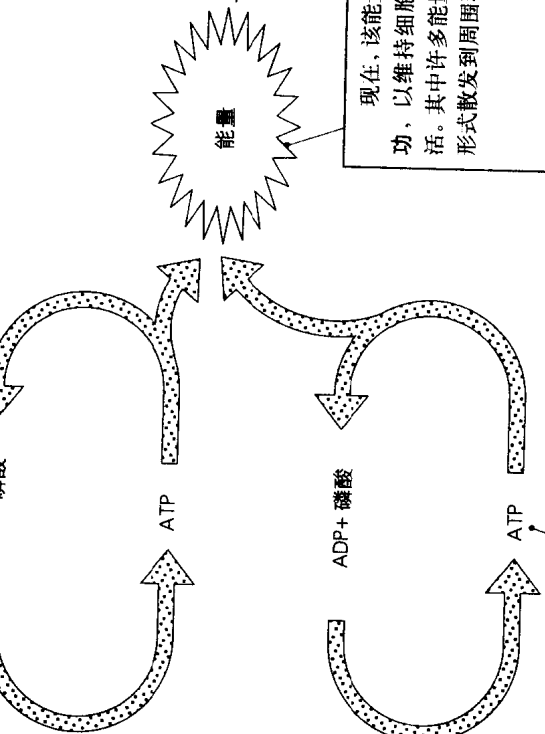


氧的消耗可以用呼吸测量。

释放的能量可用产热来测量。

温度对呼吸的作用反映了酶的介入。

二氧化碳的释放可导致：
• 石灰水变浑浊；
• 碳酸氢钠指示剂溶液从红变到黄/橘黄。



生长：包括从小分子合成大分子的过程中能量的消耗(例如，由氨基酸合成蛋白质)。

维持体温：体内发生的所有化学反应都释放热量。在肝脏和肌肉中发生的反应尤其重要。

主动转运：分子逆浓度梯度的运动，例如：离子被植物的根系吸收。

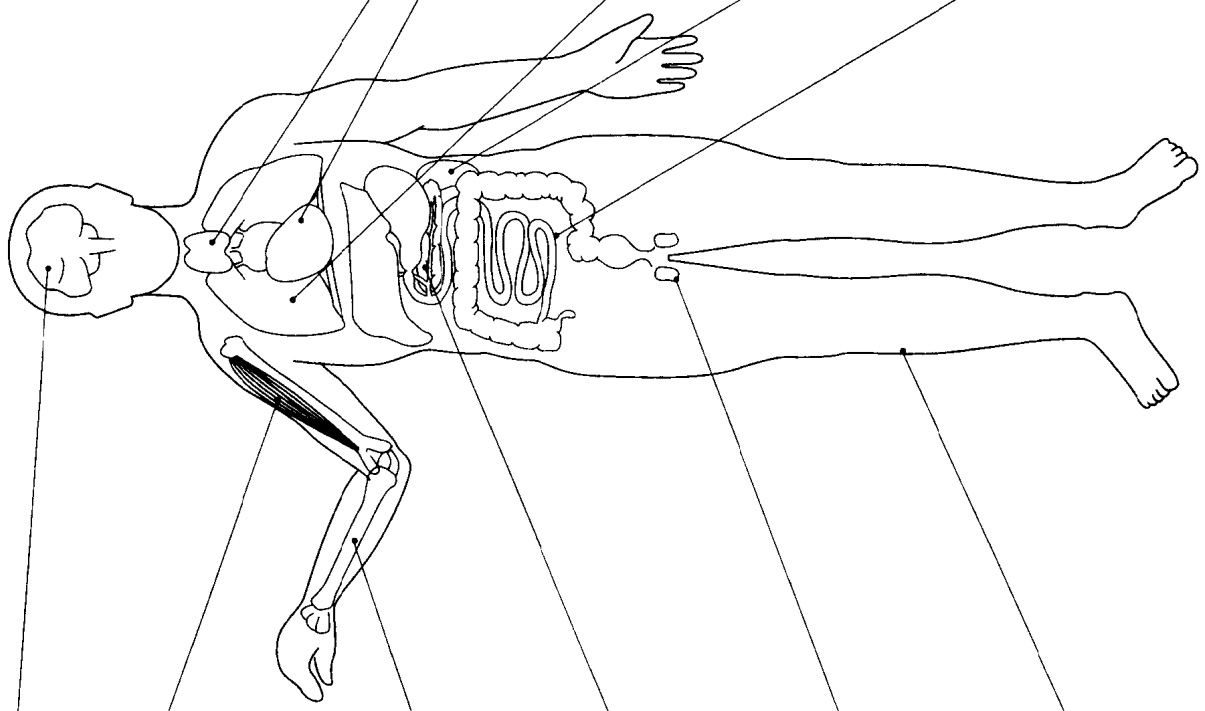
细胞分裂：染色体的复制和分离是极其耗能的过程。一个人每天需要更新数百万个细胞。

运动：肌肉的收缩需要能量。如果食物或氧的供应有限则能量的产生将不足。

ATP(腺苷三磷酸)是方便的“能量货币”，它的方便之处在于：
• 将呼吸产生的热量方便地封存起来。
• 封存的能量在需要的时候可被动用。(ATP此时降解为二磷酸核苷和磷酸)

Human body systems

all play a part in homeostasis.



The nervous system is made up of **brain, spinal cord, sense organs and peripheral nerves**. Conducts impulses responsible for integration of other systems. The principal regulatory system.

The muscular system comprises **skeletal, cardiac and smooth muscle**. Responsible for the locomotion, movement of body parts, pumping of blood and internal movement of other material. Maintains blood pressure, responsible for formation of tissue fluid.

The skeletal system consists of **bones and cartilage**. Supports the body, protects soft tissues, site of calcium storage and blood cell synthesis.

The endocrine system consists of the **ductless glands**, many of which are under the influence of the pituitary gland. These regulate many body functions, and help to keep a constant composition of the blood.

The reproductive systems comprise **testes** (male), **ovaries** (female) and associated structures. Gamete production and transfer, and maintenance of secondary sexual characteristics.

Skin, hair, nails and sweat glands protect body against infection and dehydration, help control body temperature and receive stimuli such as pressure.

HUMANS ARE MAMMALS.

- Humans
- breathe through lungs
 - have a diaphragm separating chest from abdomen
 - fertilise eggs and develop their young inside the body of the female
 - bear live young
 - feed their young on milk from specialised mammary glands
 - have some body hair, which may once have helped to make humans endothermic
- ** Humans are extremely successful because they are homeostatic (can keep a 'steady state') and thus independent of their environment**

The circulatory system is composed of two subsystems. The **cardiovascular system** (heart, blood vessels and blood) is the transportation system responsible for distribution of many solutes, and the **lymphatic system** (lymph vessels and lymph) is responsible for return of tissue fluid to blood and for defence against diseases.

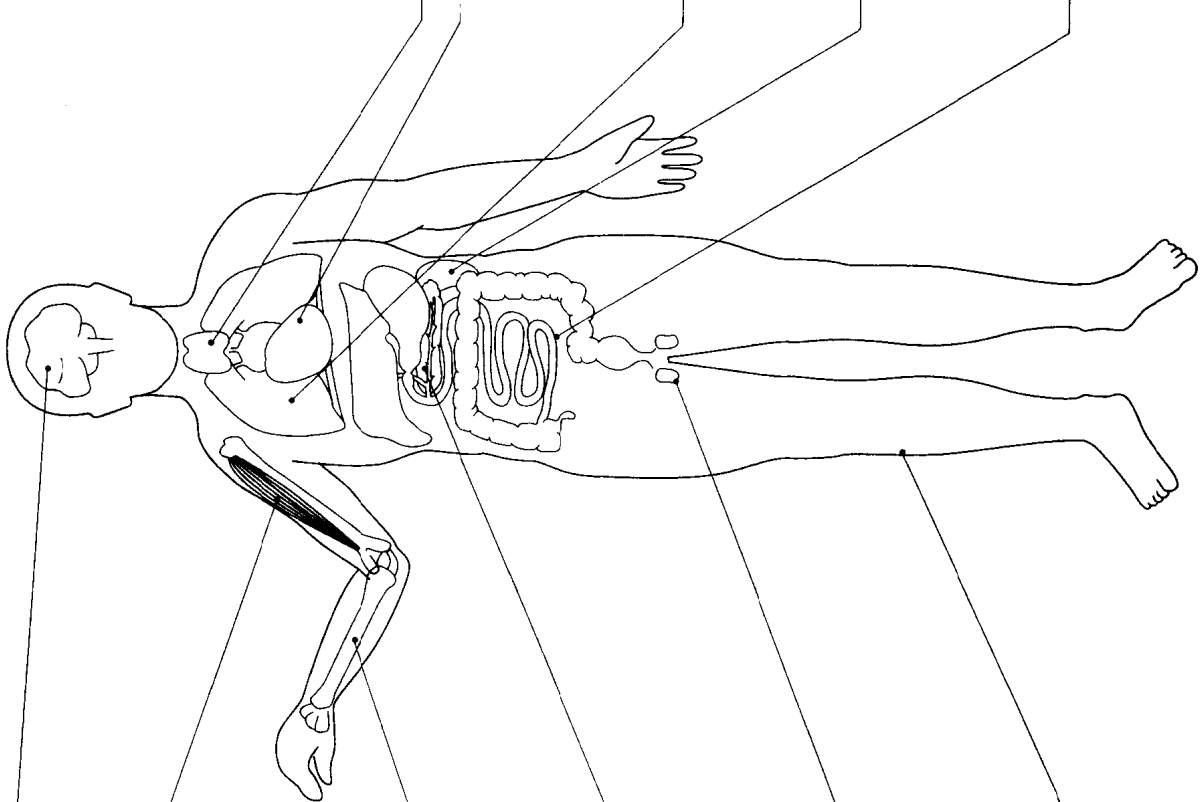
The respiratory system consists of the **lungs and air passageways** and maintains optimum concentrations of carbon dioxide and oxygen in the tissues.

The urinary system comprises the **kidneys, bladder** and associated **ducts**. These produce urine and remove it from the body. They remove toxins from, and maintain optimum solute concentrations in the blood.

The digestive system comprises **mouth, oesophagus, stomach, intestines** and accessory organs (principally **liver and pancreas**). These organs ingest food, break it down mechanically and chemically, and absorb nutrients so maintaining optimum concentrations of fuel molecules and raw materials for syntheses.

人体系统

所有器官都参与维持内环境的稳态。



神经系统 由脑、脊髓、感觉器官和外周神经组成。其发出和传导的冲动使其他系统能够协调工作。它是主要的调节系统。

肌肉系统 由骨骼、心脏和平滑肌组成。负责身体的运动、血液的输送和其他物质在体内的运动。维持血压，并产生组织液。

骨骼系统 由骨骼和软骨组成。支持身体，保护软组织，是钙的仓库和血细胞的合成部位。

内分泌系统 由无管腺组成。其中许多受脑垂体的控制。调节身体的许多机能，并保持血液中成分的稳定。

生殖系统 由睾丸(男性)和卵巢(女性)以及有关的结构组成。产生和运输配子，维持第二性征。

皮肤、毛发、指甲和汗腺 保护机体免受感染和脱水的侵害，帮助调节体温，感受压力等外界刺激。

人是哺乳动物

- 通过肺呼吸。
- 有横膈膜将胸腔和腹腔分开。
- 女性的卵在体内受精，胎儿在体内发育。
- 婴儿被娩出。
- 从特殊分化的乳腺分泌乳汁养育婴儿。
- 长有体毛，可能一度有助于人转化为恒温动物。

**** 人类在进化中的成功归功于他们是恒温动物(能保持“稳定”状态)，因此他们的内环境可相对独立于外界。**

循环系统 由两个小系统组成。
心血管系统(心脏、血管和血液)是负责运输多种溶液的运输系统；淋巴系统(淋巴管和淋巴)是将组织液返回血液和抵御疾病的系统。

呼吸系统 由肺、气体通路组成，维持组织中最佳的氧和二氧化碳的浓度。

泌尿系统 由肾脏、膀胱和相连的管道组成。这个系统产生尿液并将其排出体外。它将毒素从血中排出，维持血液中最适宜的溶质浓度。

消化系统 由口腔、食道、胃、小肠和附属器官(主要是肝脏和胰腺)组成。这些器官消化食物，用物理和化学的方式将其降解，并吸收营养。从而保持生物合成过程中能量分子和原料的最佳浓度。

Angiosperm adaptations

- more than 80% of all plant species are angiosperms (i.e. plants with enclosed seeds).

Flowers are the key to the angiosperm life cycle (angiosperms are often called **flowering plants**). In many angiosperms the colour, pattern, shape, scent or nectar of the flower attract the insects, birds and mammals. These transfer pollen from male to female parts with much greater efficiency than wind or water.

Growth, particularly of reproductive structures, can be very rapid. For example, pollination, pollen tube formation and fertilisation may take only one hour (compared to one year in some gymnosperms), and some bamboos can grow 1 metre per day.

The Ovary protects the **ovules** and **developing embryo**, particularly from desiccation (Angiosperm means "enclosed seed") so that reproductive success is more likely.

Endosperm is a store of nutrients for the developing plant embryo. It does not develop until fertilisation occurs so that food stores are not wasted, as they might be in gymnosperms.

Fruits are formed from ripened ovaries. Their specialised shapes, colours, smells and textures aid seed dispersal by wind, water and animals.

Large leaf surfaces are typical. Rapid growth and fruit production are very demanding on supplies of energy and raw material. Thus rates of photosynthesis must be high and small, needle-like leaves of gymnosperms such as pines would not be sufficient. NB Greater leaf surfaces do bring the penalty of more loss of water by evaporation and diffusion through stomata.

Stomata with guard cells to regulate loss of water vapour and movements of oxygen and carbon dioxide between plant and atmosphere.

Xylem vessels permit much more efficient water conduction than the **tracheids** found in many other plants, since there are not end walls to impede movement.

Waterproof cuticle to reduce water loss to atmosphere.

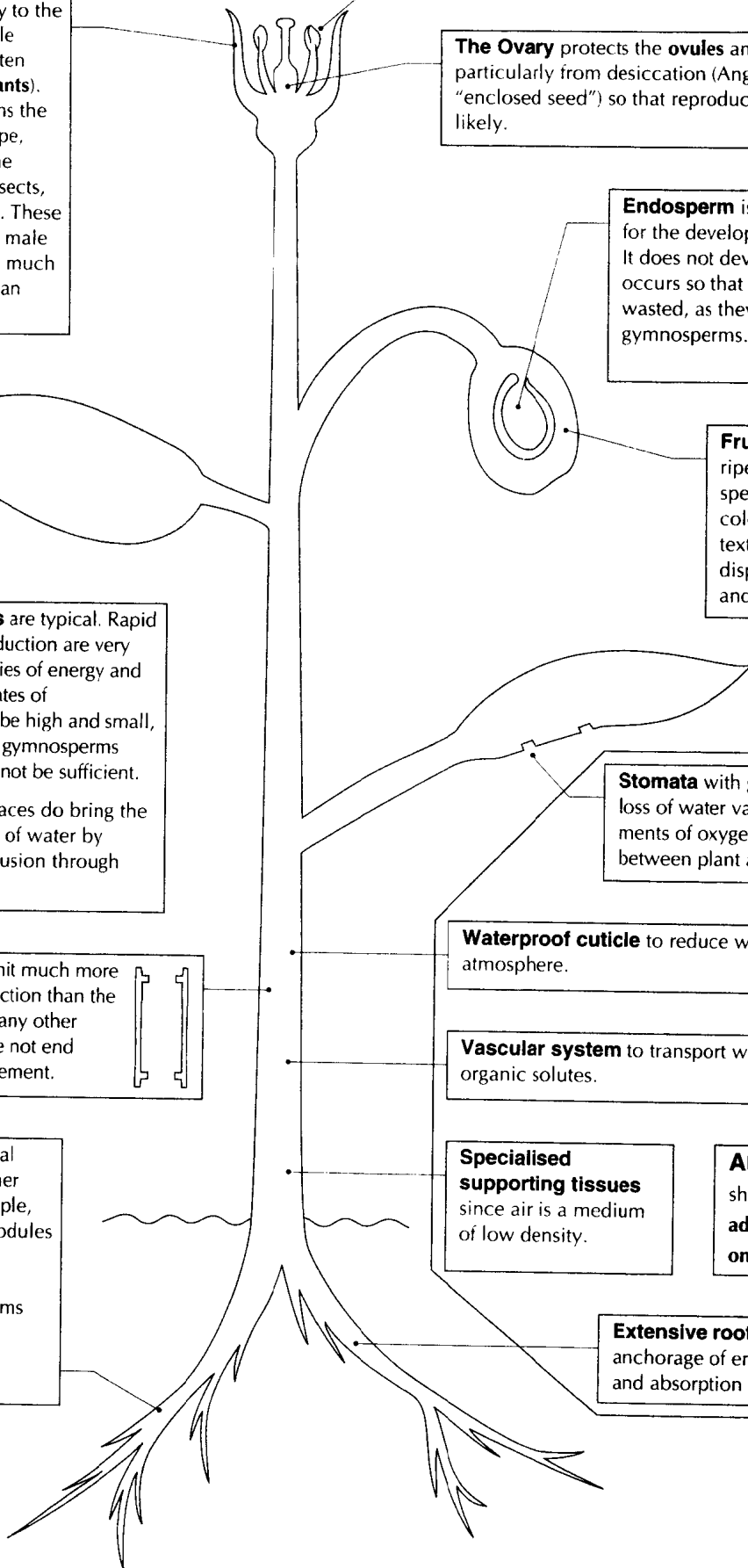
Vascular system to transport water, ions and organic solutes.

Roots form beneficial associations with other organisms. For example, legumes form root nodules with nitrogen-fixing *Rhizobium* bacteria and many Angiosperms form ion-absorbing mycorrhizae with some fungi.

Specialised supporting tissues since air is a medium of low density.

ANGIOSPERMS show basic plant adaptations to life on land

Extensive root systems for anchorage of erect shoot systems and absorption of water and ions.



被子植物的适应能力

80%以上的植物都是被子植物（即种子由壳保护的那些植物）。

被子植物的生命周期中，花是重要的阶段（被子植物常常被称作有花植物）。许多被子植物的颜色、图案、形状、味道和花蜜吸引着昆虫、鸟类和哺乳动物。这较风或水流能更有效地将花粉从雄性传递到雌性。

生长，特别是生殖结构部分，可以生长得十分迅速。例如授粉、花粉管的形成和授精过程仅仅在一个小时内就可完成（有些裸子植物需要1年），一些竹子在一天内可生长1米。

子房保护胚珠和形成过程中的胚芽，尤其是使它们免受干燥的侵害。（被子植物的含义是“有壳的种子”）。这可以保证生殖更容易获得成功。

胚乳是储存养料的部分，目的是保证植物的胚芽得到发育。胚乳直到授精以后才开始发育，因此养料的储备就不会浪费。裸子植物的情况就不是这样。

果实是成熟的子房。它们特有的形状、颜色、味道和质地使它们的种子能容易被风、水流和动物带到别处。

大的叶面是被子植物的典型特征。植物的迅速生长和结果需要大量的能量和原材料。因此光合作用的速率必须相当快，从而需要大的叶面；小的、针状的裸子植物，例如松树，不能适应这样的需求。然而大的树叶表面由于能从气孔蒸发掉更多的水分是其不利方面。

气孔和保护细胞共同调节水分的蒸发和氧、二氧化碳在植物和空气中的交换。

木质部的导管较许多其他植物的管胞能更有效地传导水分。因为没有细胞间隔阻碍水分的运输。（在蕨类植物和裸子植物中只有管胞，而无导管。）

防水的表皮 减少蒸发到大气中的水分的量。

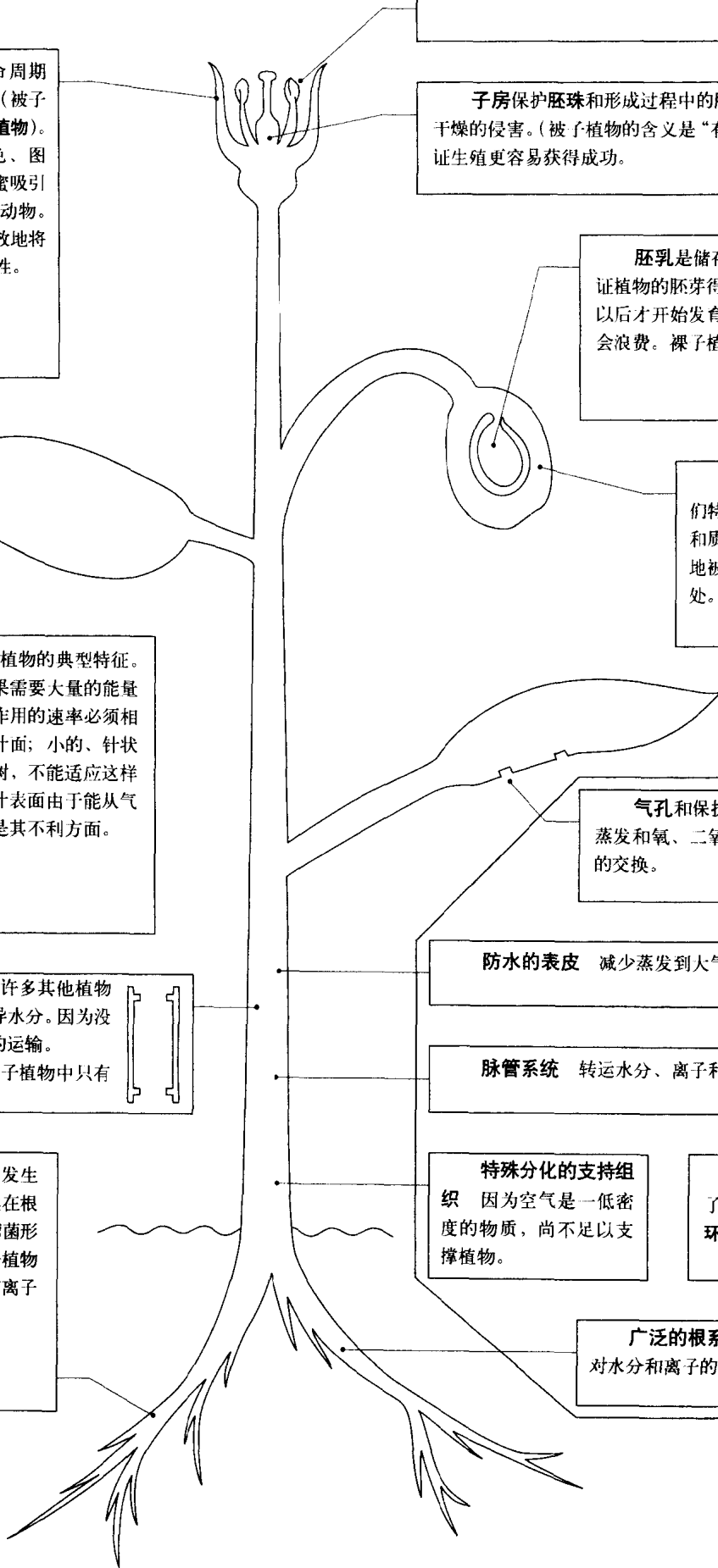
脉管系统 转运水分、离子和有机溶剂。

根与其他的生物发生有益的联系。例如豆类在根部与有固氮作用的根瘤菌形成结节，以及许多被子植物与某些真菌形成的具有离子吸收作用的菌根。

特殊分化的支持组织 因为空气是一低密度的物质，尚不足以支撑植物。

被子植物 体现了地表植物基本的适应环境的能力。

广泛的根系 保持植物的直立和对水分和离子的吸收。



Plant and animal cells

ANIMAL CELL FEATURES

often relate to heterotrophic nutrition and high rates of metabolic activity.

Secretory vesicles

containing cell products such as hormones or enzymes are much more common in animal cells.

Cytoplasm of animal cells

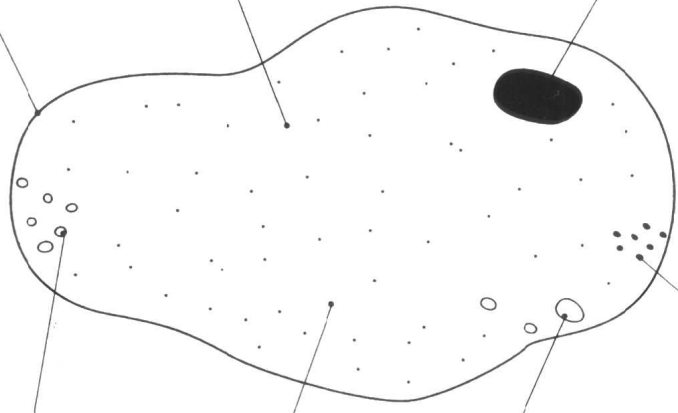
is often denser, with many more organelles and dissolved substances.

Vacuoles

are small and temporary. They can be involved with digestion (e.g. in phagocytes) or with excretion (contractile vacuoles may remove excess water).

Glycogen

is the storage form of carbohydrates.



PLANT AND ANIMAL CELLS HAVE COMMON FEATURES

which relate to maintaining the characteristics of life.

Cell membrane

which surrounds the cytoplasm. It controls the **entry and exit** of dissolved substances and is therefore responsible for separating the cells contents from its surroundings.

Cytoplasm

contains water, dissolved substances such as amino acids and sugars, and supports the various organelles (for example, mitochondria, ribosomes). It is within the cytoplasm and organelles that the various metabolic reactions needed to sustain life take place (for example, respiration).

Nucleus

contains the genetic material (**DNA** which makes up **genes** or the **chromosomes**) which carries the coded instructions controlling the activities and characteristics of the cell. The chromosomes only become visible during cell division.

PLANT CELL FEATURES

often relate to autotrophic nutrition.

Cellulose cell wall

provides structural support (pressure of cell contents leads to **turgidity**) and protects against damage caused by osmotic intake of water. It is **freely permeable to water and dissolved substances**.

Large permanent vacuole

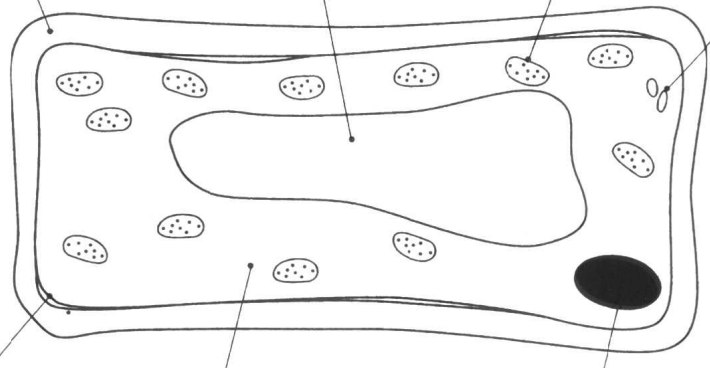
contains water necessary to provide turgor pressure and may be store for ions and molecules.

Chloroplasts

contain the pigment **chlorophyll** (light absorption) and the **enzymes** necessary for the production of glucose by photosynthesis.

Starch

(in the cytoplasm or the chloroplasts) is the storage form of carbohydrate.



The absence of the cellulose cell wall means that animal cells may be **very irregular in shape** and the limit to the amount of cytoplasm which can be controlled by the nucleus means that animal cells may be **quite small** - about 25 μ diameter.

The presence of the cellulose cell wall means that plant cells tend to be **regular in shape** and the presence of the vacuole means that plant cells may be **quite large** - often 60 μ m (or 0.06 mm) in diameter.

植物和动物细胞

动物细胞的特征

动物是高代谢率的异养生物。

分泌小泡

包含细胞产物例如激素和酶，在动物细胞中更常见。

动物的细胞质一般更加

致密，有更多的细胞器和可溶性物质。

液泡很小，存在时间短暂。

它们与消化(例如，在吞噬细胞中)或与分泌有关(具有伸缩性的液泡可将多余的水分排出)。

糖原

是储存碳水化合物的结构。

动、植物细胞与维持生命

特征有关的共同点:

细胞膜

是包裹着细胞质的结构。它控制着可溶性物质的进出，负责把细胞内容物及其周围环境分开。

细胞质

包含水、可溶性物质(例如氨基酸和糖)，并对各种细胞器提供支持作用(例如线粒体和核糖体)。在细胞浆和细胞器中发生着各种维持生命的代谢反应(例如，呼吸)。

细胞核

包含遗传物质(DNA，构成基因和染色体的物质)，该物质包含控制细胞生命活动和特征的密码。只有在细胞分裂的时候才能看清染色体。

植物细胞的特征

往往与营养自给的功能有关。

纤维素细胞壁

提供了结构上的支持(细胞内容物的压力可导致细胞膨胀)，防止渗透性吸收水分子导致的细胞肿胀。水和可溶性物质都可通过细胞壁。

大的，长期存在的液泡

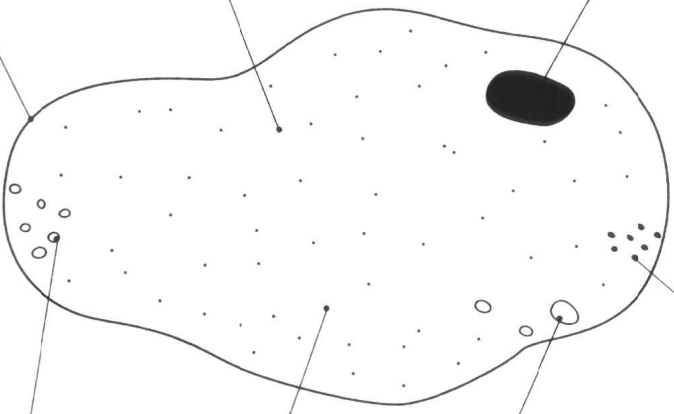
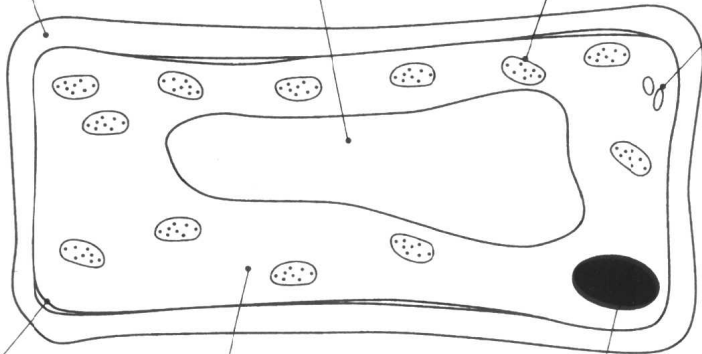
提供细胞膨胀所需的张力，也能储存离子和分子。

叶绿体

包含叶绿素(吸收光能)和由光合作用产生糖所必须的酶。

淀粉

(在细胞浆或叶绿体内)是碳水化合物的储存形式。



缺乏纤维素细胞壁的动物细胞，形状是不规则的，动物细胞核控制的胞浆含量有限，这意味着动物细胞很小，直径大约 25 微米。

纤维素的细胞壁决定了植物细胞的外观是规则的。液泡的存在意味着植物细胞可以相当大，直径常达 60 微米。

Diffusion, osmosis and active transport are processes by which molecules are moved. Diffusion and osmosis are passive, but active transport requires energy.

DIFFUSION

the movement of ions or molecules down a concentration gradient i.e. from a region of higher concentration to one of lower concentration.



This is a physical process which depends on the energy possessed by the molecules, thus

- small molecules diffuse faster than large molecules
- diffusion speeds up as temperature increases.

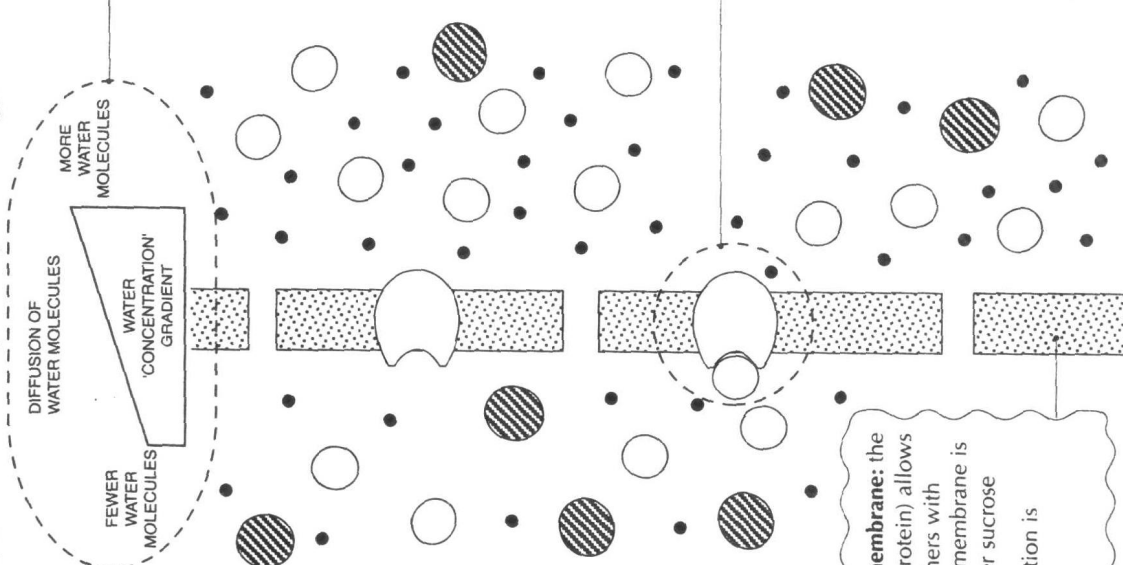
For living cells the principle (the movement of molecules down a concentration gradient) is the same, but there is one problem

the cell is surrounded by a **cell membrane** which can restrict the free movement of the molecules

Important examples

- Oxygen from air sacs in the lung to blood, and from blood to cells
- Soluble foods from gut to blood
- Carbon dioxide from air to spaces inside leaf

This is a **selectively permeable membrane**: the composition of the membrane (lipid and protein) allows some molecules to cross with ease, but others with difficulty or not at all. In this example the membrane is permeable to water ● but not to the larger sucrose molecule ◐ - the simplest sort of selection is based on the **size** of the molecules.



OSMOSIS IS THE DIFFUSION OF WATER

Water crosses membranes very freely and always tends to move, by diffusion, down the water 'concentration' gradient. The term 'concentration' can be confusing when used to describe water molecules, and is better replaced by the term 'potential'.

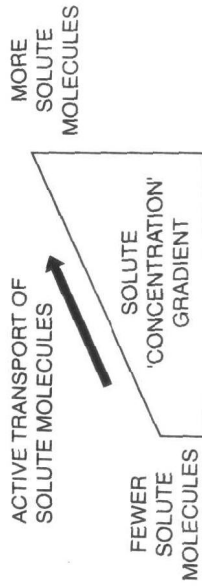
Thus osmosis is

- the movement of water
- across a selectively permeable membrane
- down a water potential gradient

Osmosis is responsible for water movement

- from tissue fluid to cells
- from soil water to root hairs
- from xylem to leaf mesophyll cells

ACTIVE TRANSPORT MAY MOVE MOLECULES AGAINST A CONCENTRATION GRADIENT



In this example there are more amino acid molecules on the right side of the membrane than on the left - to move any more from left to right will be 'uphill', **against** the amino acid gradient. This active transport

- requires energy to 'drive' the molecules 'uphill' - this energy is supplied as ATP from respiration
- is affected by any factor which affects respiration, e.g. temperature and oxygen concentration
- is carried out by 'carrier proteins' in the membrane, which bind to the solute molecule, change shape, and carry the molecule across the membrane.

Important examples are

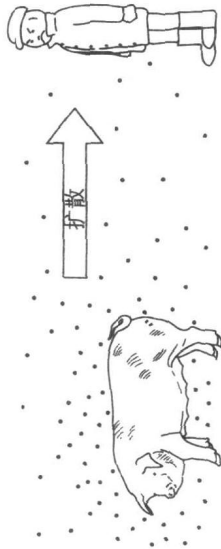
- uptake of mineral ions from soil by root hair cells
- movement of sodium ions to set up nerve impulses

扩散、渗透和主动转运

是分子运动的过程，扩散和渗透是被动的，而主动转运则需要有能量。

扩散

离子或分子的运动顺着浓度的梯度，例如：从高浓度到低浓度。



这个物理过程依赖分子本身具有的能量，因此，

- 小分子较大分子扩散更快，
- 随着温度的上升，扩散的速度也加快。

对于活细胞，分子顺着浓度梯度运动的原理

是一样的，但这里有一个问题

→ 细胞的外面

是细胞膜，这层膜可限制分子的自由移动。

重要的例子：

- 氧气从肺部进入血液，和氧气从血液进入细胞。
- 可溶性食物由小肠进入血液。
- 二氧化碳从空气中进入到叶子内部空间。

这是一个选择性渗透膜，膜的构成(脂和蛋白)允许一些分子容易地通过，但另外一些分子则比较难或根本不可以。在这个例子中，膜对水是可通透的，对大的蔗糖分子却不能。选择过程最根本前提就是基于分子的大小。

渗透作用是水的扩散。

水能以扩散的方式，顺着浓度梯度，很自由地通过细胞膜。“浓度”在表示水分子的时候有些令人不解，用“势能”一词可能更好。

渗透是

- 水的运动。
- 通过一选择性可渗透的膜。
- 顺着水的势能梯度。

渗透作用与水的(下述)运动有关

- 从组织液到细胞。
- 从土壤中的水到根毛。
- 从木质部到叶肉细胞。

主动转运可将物质逆浓度梯度进行转运

可溶性分子的主动转运



在此示意图上，细胞膜的右边有更多的氨基酸分子。将左侧的分子移动到右侧，就如同逆着氨基酸的浓度梯度“上山”。主动转运过程

- 要求有能量用于“推动”分子“上山”。能量由呼吸产生的ATP产生。
- 受到任何影响呼吸的因素的影响，比如：温度或氧浓度。
- 具体由细胞膜上的“转运蛋白”完成，转运蛋白与可溶性分子结合，改变形状，将分子作跨膜转运。

重要的例子是

- 根毛细胞从土壤中吸收矿物质。
- 产生神经冲动的钠离子的运动。

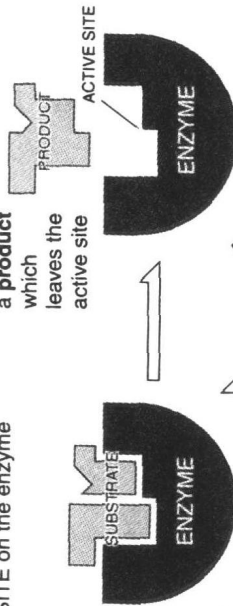
Enzymes control biological process

and are widely exploited by humans.

ENZYMES ARE PROTEINS WHICH ACT AS CATALYSTS IN LIVING ORGANISMS

Substrate molecules fit exactly onto an ACTIVE SITE on the enzyme

Substrate molecules react together to form a product which leaves the active site



Enzyme molecule is now free to bind to more substrate molecules

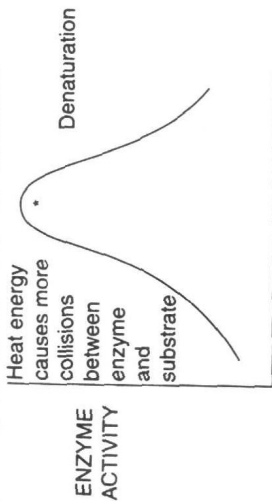
The shape of the active site enables the enzyme to 'recognise' its substrate in a very specific way. Any factor which alters the enzyme's shape will affect its activity.

Inhibitors and activators: these are molecules which may

- **inhibit** by blocking the active site e.g. cyanide poisons by blocking enzymes in respiration
- **activate** by helping the active site to achieve its correct shape e.g. chloride ions in saliva activate the starch digesting enzyme salivary amylase

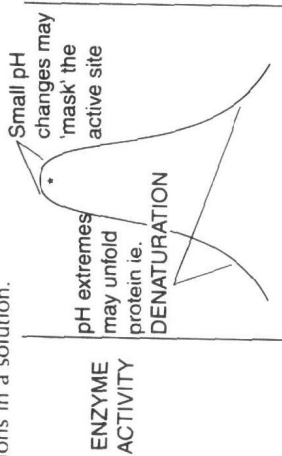
these are **made** inside cells but **have their action** outside the cell ('extra' means 'outside') e.g. digestive systems in the human gut enzymes released by saprotrophic fungi and bacteria

TEMPERATURE: like all proteins, enzymes are made up of long, precisely folded chains of amino acids. This folding may be 'undone' by high temperature so that the enzyme may lose its active site - it is **denatured**.



* The optimum temperature for human enzymes is close to 37°C. For most plants it is lower.

pH: is a measure of acidity or alkalinity, and is a mathematical method for expressing the concentration of H⁺ ions in a solution.



* the optimum pH for an enzyme depends on its site of action e.g. enzymes in the stomach (where HCl is present) have an optimum about pH 2 but intestinal enzymes (no HCl) have optimum pH about 7.5

Enzymes may be intracellular or extracellular

these are both made **and** have their action inside cells ('intra' means 'inside') e.g. photosynthetic enzymes inside chloroplasts respiratory enzymes inside mitochondria.

THE SPECIFICITY AND CATALYTIC ACTIVITY OF ENZYMES MAKES THEM VERY USEFUL TO HUMANS

MEDICINE

- **Streptokinase** limits damage caused by heart attacks by dissolving blood clots
- **Urease** breaks down urea in dialysis fluid from kidney dialysis machines, allowing the fluid to be reused
- **Lactase** removes lactose from milk, thus making it safe for lactose-intolerant people

COMMERCIAL

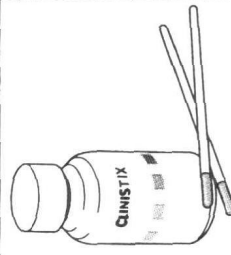
- **Proteases** help to soften leather for the garment industry
- **Lipase** removes stains from clothing - component of 'biological' washing powders
- **Amylase** converts starch to sugars used in production of syrups, e.g. in fruit pies

PHARMACEUTICAL

- **Proteases** remove protein stains from false teeth
- **Catalase** removes hydrogen peroxide used to sterilise contact lenses

ANALYTICAL

- **Glucose oxidase** used in biosensors detects glucose levels in blood and urine
- **Carbonic anhydrase** detects levels of insecticides in water



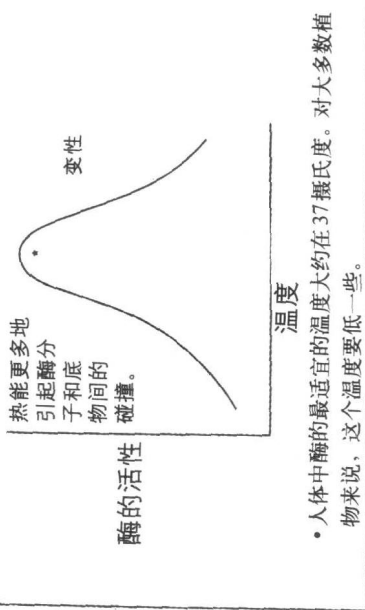
GENETIC ENGINEERING

- **Restriction enzymes** are used to cut out specific genes, and to open up bacterial plasmids
- **Ligases** are used to 'stitch' human genes into bacterial plasmids

Other, related topics can be found on pages 11, 46.

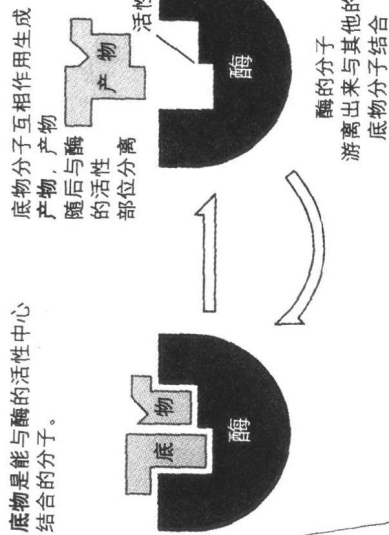
酶对生物反应的控制作用

被人类加以广泛的利用。



酶是生物体中起催化作用的蛋白质。

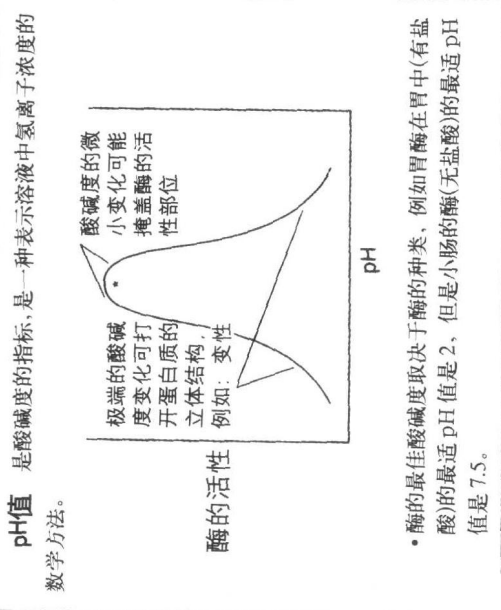
底物是能酶的活性中心结合分子。



活性区域的形状使得酶能够以精确的方式辨认底物。任何可以影响酶结构的因素都可影响它的活性。

抑制剂和激活剂 是有以下特点分子：

- 通过阻滞活性部位达到阻滞作用。例如氰酸盐阻碍呼吸中的酶。
- 激活剂能帮助活性部位恢复正常形状达到激活作用。例如：氯化物的离子在唾液中激活淀粉消化酶 - 唾液淀粉酶。



酶可以是细胞内的，也可以是细胞外的。

细胞内酶的含义是在细胞内产生和在细胞内作用的。
例如：叶绿体内光合作用的酶，线粒体中的呼吸酶。

细胞外酶的定义是在细胞内产生但在细胞外作用。
例如：在人类的消化系统中，由肠道的腐生真菌和细菌产生的消化酶。

用

酶的特异性和催化活性使它们对人类十分有用

药物

- **溶栓酶(链激酶)** 通过溶解血栓使心肌梗梗的后果减到最小。
- **尿素酶** 降解肾脏透析仪中的透析液中的尿素，允许透析液被重新使用。
- **乳糖酶** 将牛奶中的乳糖除去，这样不能耐受乳糖的人就能服用。

商业

- **蛋白酶** 在服装工业中帮助软化(鞣制)皮革。
- **脂肪酶** “生物”洗衣粉的配料之一，去除衣物上的污物。
- **淀粉酶** 将淀粉转化为生产糖浆所用的糖，例如：制造果子饼。

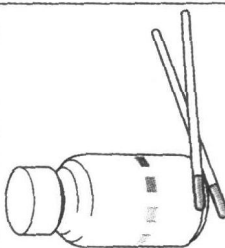
制药工业

- **蛋白酶** 将假牙中的蛋白污点除去。
- **过氧化氢酶** 消除过氧化氢，用于消毒隐形眼镜。



分析

- **葡萄糖氧化酶** 用于生物感受器，探索血液和尿中的葡萄糖水平。
- **碳酸酐酶** 探索水中的杀虫剂水平。



基因工程

- **限制酶** 用以切断特定的基因，打开细菌的质粒。
 - **连接酶** 将人类的基因“粘”入细菌的质粒。
- 其他相关主题参见第 11、46 页。