A-Level Biology

Syllabus Checklist · 大纲自查表

Tick one box per statement: ☐ not yet ☐ nearly ☐ confident. 每条打一个勾：尚未掌握 / 快会了 / 有把握。

1. Cell structure 细胞结构

1.1 The microscope in cell studies 显微镜在细胞研究中的应用

- ☐☐☐ make temporary preparations of cellular material suitable for viewing with a **light microscope**
- ☐☐☐ draw cells from microscope slides and **photomicrographs**
- ☐☐☐ calculate **magnifications** of images and actual sizes of specimens from drawings, photomicrographs and **electron micrographs** (scanning and transmission)
- ☐☐☐ use an **eyepiece graticule** and **stage micrometer** scale to make measurements and use the appropriate units, millimetre (mm), micrometre (µm) and nanometre (nm)
- ☐☐☐ define **resolution** and **magnification** and explain the differences between these terms, with reference to light microscopy and electron microscopy

1.2 Cells as the basic units of living organisms 细胞作为生物体的基本单位

- ☐☐☐ recognise **organelles** and other cell structures found in **eukaryotic cells** and outline their structures and functions, limited to: • cell surface membrane • nucleus, nuclear envelope and nucleolus • rough endoplasmic reticulum • smooth endoplasmic reticulum • Golgi body (Golgi apparatus or Golgi complex) • mitochondria (including the presence of small circular DNA) • ribosomes (80S in the cytoplasm and 70S in chloroplasts and mitochondria) • lysosomes • centrioles and microtubules • cilia • microvilli • chloroplasts (including the presence of small circular DNA) • cell wall • plasmodesmata • large permanent vacuole and tonoplast of plant cells
- ☐☐☐ describe and interpret photomicrographs, electron micrographs and drawings of typical plant and animal cells
- ☐☐☐ compare the structure of typical plant and animal cells
- ☐☐☐ state that cells use **ATP** from **respiration** for energy-requiring processes
- ☐☐☐ outline key structural features of a **prokaryotic cell** as found in a typical bacterium, including: • unicellular • generally 1–5 μm diameter • peptidoglycan cell walls • circular DNA • 70S ribosomes • absence of organelles surrounded by double membranes
- ☐☐☐ compare the structure of a prokaryotic cell as found in a typical bacterium with the structures of typical eukaryotic cells in plants and animals
- ☐☐☐ state that all **viruses** are non-cellular structures with a **nucleic acid core** (either DNA or RNA) and a **capsid** made of protein, and that some viruses have an outer envelope made of phospholipids

2. Biological molecules 生物分子

2.1 Testing for biological molecules 生物分子的检测

- ☐☐☐ describe and carry out the **Benedict's test** for **reducing sugars**, the **iodine test** for **starch**, the **emulsion test** for **lipids** and the **biuret test** for **proteins**
- ☐☐☐ describe and carry out a **semi-quantitative** Benedict's test on a reducing sugar solution by standardising the test and using the results (time to first colour change or comparison to colour standards) to estimate the concentration
- ☐☐☐ describe and carry out a test to identify the presence of **non-reducing sugars**, using **acid hydrolysis** and Benedict's solution

2.2 Carbohydrates and lipids 糖类与脂质

- ☐☐☐ describe and draw the ring forms of **α-glucose** and **β-glucose**
- ☐☐☐ define the terms **monomer**, **polymer**, **macromolecule**, **monosaccharide**, **disaccharide** and **polysaccharide**
- ☐☐☐ state the role of **covalent bonds** in joining smaller molecules together to form polymers
- ☐☐☐ state that **glucose**, **fructose** and **maltose** are **reducing sugars** and that **sucrose** is a **non-reducing sugar**
- ☐☐☐ describe the formation of a **glycosidic bond** by **condensation**, with reference to disaccharides, including sucrose, and polysaccharides
- ☐☐☐ describe the breakage of a glycosidic bond in polysaccharides and disaccharides by **hydrolysis**, with reference to the non-reducing sugar test
- ☐☐☐ describe the molecular structure of the polysaccharides **starch** (**amylose** and **amylopectin**) and **glycogen** and relate their structures to their functions in living organisms
- ☐☐☐ describe the molecular structure of the polysaccharide **cellulose** and outline how the arrangement of cellulose molecules contributes to the function of **plant cell walls**
- ☐☐☐ state that **triglycerides** are non-polar hydrophobic molecules and describe the molecular structure of triglycerides with reference to **fatty acids** (**saturated** and **unsaturated**), **glycerol** and the formation of **ester bonds**
- ☐☐☐ relate the molecular structure of triglycerides to their functions in living organisms
- ☐☐☐ describe the molecular structure of **phospholipids** with reference to their **hydrophilic** (polar) **phosphate heads** and **hydrophobic** (non-polar) **fatty acid tails**

2.3 Proteins 蛋白质

- ☐☐☐ describe and draw the general structure of an **amino acid** and the formation and breakage of a **peptide bond**
- ☐☐☐ explain the meaning of the terms **primary structure**, **secondary structure**, **tertiary structure** and **quaternary structure** of proteins
- ☐☐☐ describe the types of interaction that hold protein molecules in shape: • **hydrophobic interactions** • **hydrogen bonding** • **ionic bonding** • **covalent bonding**, including **disulfide bonds**
- ☐☐☐ state that **globular proteins** are generally soluble and have physiological roles and **fibrous proteins** are generally insoluble and have structural roles
- ☐☐☐ describe the structure of a molecule of **haemoglobin** as an example of a globular protein, including the formation of its quaternary structure from two alpha (α) chains (α–**globin**), two beta (β) chains (β–**globin**) and a **haem group**
- ☐☐☐ relate the structure of haemoglobin to its function, including the importance of **iron** in the haem group
- ☐☐☐ describe the structure of a molecule of **collagen** as an example of a fibrous protein, and the arrangement of collagen molecules to form **collagen fibres**
- ☐☐☐ relate the structures of collagen molecules and collagen fibres to their function

2.4 Water 水

- ☐☐☐ explain how **hydrogen bonding** occurs between water molecules and relate the properties of water to its roles in living organisms, limited to **solvent action**, high **specific heat capacity** and **latent heat of vaporisation**

3. Enzymes 酶

3.1 Mode of action of enzymes 酶的作用机制

- ☐☐☐ state that **enzymes** are globular proteins that catalyse reactions inside cells (**intracellular enzymes**) or are secreted to catalyse reactions outside cells (**extracellular enzymes**)
- ☐☐☐ explain the mode of action of enzymes in terms of an **active site**, **enzyme–substrate complex**, lowering of **activation energy** and **enzyme specificity**, including the **lock-and-key hypothesis** and the **induced-fit hypothesis**
- ☐☐☐ investigate the progress of enzyme-catalysed reactions by measuring rates of formation of products using **catalase** and rates of disappearance of substrate using **amylase**
- ☐☐☐ outline the use of a **colorimeter** for measuring the progress of enzyme-catalysed reactions that involve colour changes

3.2 Factors that affect enzyme action 影响酶活性的因素

- ☐☐☐ investigate and explain the effects of the following factors on the rate of enzyme-catalysed reactions: • **temperature** • **pH** (using buffer solutions) • **enzyme concentration** • **substrate concentration** • **inhibitor concentration**
- ☐☐☐ explain that the **maximum rate of reaction** ($V_{\max}$) is used to derive the **Michaelis–Menten constant** (K_{m}), which is used to compare the **affinity** of different enzymes for their substrates
- ☐☐☐ explain the effects of **reversible inhibitors**, both **competitive** and **non-competitive**, on enzyme activity
- ☐☐☐ investigate the difference in activity between an enzyme **immobilised** in **alginate** and the same enzyme free in solution, and state the advantages of using **immobilised enzymes**

4. Cell membranes and transport 细胞膜与物质运输

4.1 Fluid mosaic membranes 流动镶嵌模型膜

- ☐☐☐ describe the **fluid mosaic model** of membrane structure with reference to the hydrophobic and hydrophilic interactions that account for the formation of the **phospholipid bilayer** and the arrangement of proteins
- ☐☐☐ describe the arrangement of **cholesterol**, **glycolipids** and **glycoproteins** in **cell surface membranes**
- ☐☐☐ describe the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins in cell surface membranes, with reference to stability, fluidity, permeability, transport (**carrier proteins** and **channel proteins**), **cell signalling** (**cell surface receptors**) and **cell recognition** (**cell surface antigens** – see 11.1.2)
- ☐☐☐ outline the main stages in the process of cell signalling leading to specific responses: • secretion of specific chemicals (**ligands**) from cells • transport of ligands to **target cells** • binding of ligands to cell surface receptors on target cells

4.2 Movement into and out of cells 物质进出细胞的运输

- ☐☐☐ describe and explain the processes of **simple diffusion**, **facilitated diffusion**, **osmosis**, **active transport**, **endocytosis** and **exocytosis**
- ☐☐☐ investigate simple diffusion and osmosis using plant tissue and non-living materials, including **dialysis (Visking) tubing** and agar
- ☐☐☐ illustrate the principle that **surface area to volume ratios** decrease with increasing size by calculating surface areas and volumes of simple 3-D shapes (as shown in the Mathematical requirements)
- ☐☐☐ investigate the effect of changing surface area to volume ratio on diffusion using agar blocks of

different sizes

- ☐☐☐ investigate the effects of immersing plant tissues in solutions of different **water potentials**, using the results to estimate the water potential of the tissues
- ☐☐☐ explain the movement of water between cells and solutions in terms of water potential and explain the different effects of the movement of water on plant cells and animal cells (knowledge of solute potential and pressure potential is not expected)

5. The mitotic cell cycle 有丝分裂细胞周期

5.1 Replication and division of nuclei and cells 细胞核与细胞的复制和分裂

- ☐☐☐ describe the structure of a **chromosome**, limited to: • DNA • **histone proteins** • **sister chromatids** • **centromere** • **telomeres**
- ☐☐☐ explain the importance of **mitosis** in the production of **genetically identical daughter cells** during: • growth of multicellular organisms • replacement of damaged or dead cells • repair of tissues by cell replacement • asexual reproduction
- ☐☐☐ outline the **mitotic cell cycle**, including: • **interphase** (growth in G_1 and G_2 phases and DNA replication in S phase) • mitosis • **cytokinesis**
- ☐☐☐ outline the role of telomeres in preventing the loss of genes from the ends of chromosomes during DNA replication
- ☐☐☐ outline the role of **stem cells** in cell replacement and tissue repair by mitosis
- ☐☐☐ explain how **uncontrolled cell division** can result in the formation of a **tumour**

5.2 Chromosome behaviour in mitosis 有丝分裂中染色体的行为

- ☐☐☐ describe the behaviour of chromosomes in plant and animal cells during the mitotic cell cycle and the associated behaviour of the nuclear envelope, the cell surface membrane and the spindle (names of the main stages of mitosis are expected: **prophase**, **metaphase**, **anaphase** and **telophase**)
- ☐☐☐ interpret photomicrographs, diagrams and microscope slides of cells in different stages of the mitotic cell cycle and identify the main stages of mitosis

6. Nucleic acids and protein synthesis 核酸与蛋白质合成

6.1 Structure of nucleic acids and replication of DNA 核酸的结构与 DNA 的复制

- ☐☐☐ describe the structure of **nucleotides**, including the phosphorylated nucleotide **ATP** (structural formulae are not expected)
- ☐☐☐ state that the bases **adenine** and **guanine** are **purines** with a double ring structure, and that the bases **cytosine**, **thymine** and **uracil** are **pyrimidines** with a single ring structure (structural formulae for bases are not expected)
- ☐☐☐ describe the structure of a DNA molecule as a **double helix**, including: • the importance of **complementary base pairing** between the 5′ to 3′ strand and the 3′ to 5′ strand (**antiparallel strands**) • differences in hydrogen bonding between C–G and A–T base pairs • linking of nucleotides by **phosphodiester bonds**
- ☐☐☐ describe the **semi-conservative replication** of DNA during the S phase of the cell cycle, including: • the roles of **DNA polymerase** and **DNA ligase** (knowledge of other enzymes in DNA replication in cells and different types of DNA polymerase is not expected) • the differences between **leading strand** and **lagging strand** replication as a consequence of DNA polymerase adding nucleotides only in a 5′ to 3′ direction
- ☐☐☐ describe the structure of an RNA molecule, using the example of **messenger RNA (mRNA)**

6.2 Protein synthesis 蛋白质合成

- ☐☐☐ state that a **polypeptide** is coded for by a **gene** and that a gene is a sequence of nucleotides that forms part of a DNA molecule
- ☐☐☐ describe the principle of the **universal genetic code** in which different **triplets** of DNA bases either code for specific amino acids or correspond to **start and stop codons**
- ☐☐☐ describe how the information in DNA is used during **transcription** and **translation** to construct polypeptides, including the roles of: • **RNA polymerase** • messenger RNA (mRNA) • **codons** • **transfer RNA (tRNA)** • **anticodons** • **ribosomes**
- ☐☐☐ state that the strand of a DNA molecule that is used in transcription is called the transcribed or **template strand** and that the other strand is called the **non-transcribed strand**
- ☐☐☐ explain that, in eukaryotes, the RNA molecule formed following transcription (primary transcript) is modified by the removal of non-coding sequences (**introns**) and the joining together of coding sequences (**exons**) to form mRNA
- ☐☐☐ state that a **gene mutation** is a change in the sequence of base pairs in a DNA molecule that may result in an altered polypeptide
- ☐☐☐ explain that a gene mutation is a result of **substitution** or **deletion** or **insertion** of nucleotides in DNA and outline how each of these types of mutation may affect the polypeptide produced

7. Transport in plants 植物体内的运输

7.1 Structure of transport tissues 运输组织的结构

- ☐☐☐ draw plan diagrams of transverse sections of stems, roots and leaves of **herbaceous dicotyledonous plants** from microscope slides and photomicrographs
- ☐☐☐ describe the distribution of **xylem** and **phloem** in transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants
- ☐☐☐ draw and label **xylem vessel elements**, **phloem sieve tube elements** and **companion cells** from microscope slides, photomicrographs and electron micrographs
- ☐☐☐ relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions

7.2 Transport mechanisms 运输机制

- ☐☐☐ state that some **mineral ions** and **organic compounds** can be transported within plants dissolved in water
- ☐☐☐ describe the transport of water from the soil to the xylem through the: • **apoplast pathway**, including reference to **lignin** and cellulose • **symplast pathway**, including reference to the **endodermis**, **Casparian strip** and **suberin**
- ☐☐☐ explain that **transpiration** involves the evaporation of water from the internal surfaces of leaves followed by diffusion of water vapour to the atmosphere
- ☐☐☐ explain how hydrogen bonding of water molecules is involved with movement of water in the xylem by **cohesion-tension** in **transpiration pull** and by **adhesion** to cellulose in cell walls
- ☐☐☐ make annotated drawings of transverse sections of leaves from **xerophytic plants** to explain how they are adapted to reduce water loss by transpiration
- ☐☐☐ state that **assimilates** dissolved in water, such as sucrose and amino acids, move from **sources to sinks** in phloem sieve tubes
- ☐☐☐ explain how companion cells transfer assimilates to phloem sieve tubes, with reference to **proton pumps** and **cotransporter proteins**
- ☐☐☐ explain **mass flow** in phloem sieve tubes down a **hydrostatic pressure gradient** from source to sink

8. Transport in mammals 哺乳动物体内的运输

8.1 The circulatory system 循环系统

- ☐☐☐ state that the mammalian circulatory system is a closed **double circulation** consisting of a heart, blood and blood vessels including **arteries**, **arterioles**, **capillaries**, **venules** and **veins**
- ☐☐☐ describe the functions of the main blood vessels of the **pulmonary** and **systemic circulations**, limited to **pulmonary artery**, **pulmonary vein**, **aorta** and **vena cava**
- ☐☐☐ recognise arteries, veins and capillaries from microscope slides, photomicrographs and electron micrographs and make plan diagrams showing the structure of arteries and veins in transverse section (TS) and longitudinal section (LS)
- ☐☐☐ explain how the structure of muscular arteries, elastic arteries, veins and capillaries are each related to their functions
- ☐☐☐ recognise and draw **red blood cells**, **monocytes**, **neutrophils** and **lymphocytes** from microscope slides, photomicrographs and electron micrographs
- ☐☐☐ state that water is the main component of blood and tissue fluid and relate the properties of water to its role in transport in mammals, limited to solvent action and high specific heat capacity
- ☐☐☐ state the functions of **tissue fluid** and describe the formation of tissue fluid in a **capillary network**

8.2 Transport of oxygen and carbon dioxide 氧气与二氧化碳的运输

- ☐☐☐ describe the role of red blood cells in transporting **oxygen** and **carbon dioxide** with reference to the roles of: • haemoglobin • **carbonic anhydrase** • the formation of **haemoglobinic acid** • the formation of **carbaminohaemoglobin**
- ☐☐☐ describe the **chloride shift** and explain the importance of the chloride shift
- ☐☐☐ describe the role of plasma in the transport of carbon dioxide
- ☐☐☐ describe and explain the **oxygen dissociation curve** of adult haemoglobin
- ☐☐☐ explain the importance of the oxygen dissociation curve at partial pressures of oxygen in the lungs and in respiring tissues
- ☐☐☐ describe the **Bohr shift** and explain the importance of the Bohr shift

8.3 The heart 心脏

- ☐☐☐ describe the external and internal structure of the **mammalian heart**
- ☐☐☐ explain the differences in the thickness of the walls of the: • **atria** and **ventricles** • **left ventricle** and **right ventricle**
- ☐☐☐ describe the **cardiac cycle**, with reference to the relationship between blood pressure changes during **systole** and **diastole** and the opening and closing of **valves**
- ☐☐☐ explain the roles of the **sinoatrial node**, the **atrioventricular node** and the **Purkyne tissue** in the cardiac cycle (knowledge of nervous and hormonal control is not expected)

9. Gas exchange 气体交换

9.1 The gas exchange system 气体交换系统

- ☐☐☐ describe the structure of the human **gas exchange system**, limited to: • **lungs** • **trachea** • **bronchi** • **bronchioles** • **alveoli** • **capillary network**
- ☐☐☐ describe the distribution in the gas exchange system of **cartilage**, **ciliated epithelium**, **goblet cells**, **squamous epithelium** of alveoli, **smooth muscle** and capillaries
- ☐☐☐ recognise cartilage, ciliated epithelium, goblet cells, squamous epithelium of alveoli, smooth muscle and capillaries in microscope slides, photomicrographs and electron micrographs
- ☐☐☐ recognise trachea, bronchi, bronchioles and alveoli in microscope slides, photomicrographs and electron micrographs and make plan diagrams of transverse sections of the walls of the trachea and bronchus
- ☐☐☐ describe the functions of ciliated epithelial cells, goblet cells and **mucous glands** in maintaining the health of the gas exchange system
- ☐☐☐ describe the functions in the gas exchange system of cartilage, smooth muscle, elastic fibres and squamous epithelium
- ☐☐☐ describe gas exchange between air in the alveoli and blood in the capillaries

10. Infectious diseases 传染病

10.1 Infectious diseases 传染病

- ☐☐☐ state that **infectious diseases** are caused by **pathogens** and are transmissible
- ☐☐☐ state the name and type of pathogen that causes each of the following diseases: • **cholera** – caused by the bacterium **Vibrio cholerae** • **malaria** – caused by the protoctists **Plasmodium falciparum**, Plasmodium malariae, Plasmodium ovale and Plasmodium vivax • **tuberculosis (TB)** – caused by the bacteria **Mycobacterium tuberculosis** and Mycobacterium bovis • **HIV/AIDS** – caused by the **human immunodeficiency virus (HIV)**
- ☐☐☐ explain how cholera, malaria, TB and HIV are transmitted
- ☐☐☐ discuss the biological, social and economic factors that need to be considered in the prevention and control of cholera, malaria, TB and HIV (details of the life cycle of the malarial parasite are not expected)

10.2 Antibiotics 抗生素

- ☐☐☐ outline how **penicillin** acts on bacteria and why **antibiotics** do not affect viruses
- ☐☐☐ discuss the consequences of **antibiotic resistance** and the steps that can be taken to reduce its impact

11. Immunity 免疫

11.1 The immune system 免疫系统

- ☐☐☐ describe the mode of action of **phagocytes** (macrophages and neutrophils)
- ☐☐☐ explain what is meant by an **antigen** (see 4.1.3) and state the difference between **self antigens** and **non-self antigens**
- ☐☐☐ describe the sequence of events that occurs during a **primary immune response** with reference to the roles of: • macrophages • **B-lymphocytes**, including **plasma cells** • **T-lymphocytes**, limited to **T-helper cells** and **T-killer cells**
- ☐☐☐ explain the role of **memory cells** in the **secondary immune response** and in long-term immunity

11.2 Antibodies and vaccination 抗体与疫苗接种

- ☐☐☐ relate the molecular structure of **antibodies** to their functions
- ☐☐☐ outline the **hybridoma method** for the production of **monoclonal antibodies**
- ☐☐☐ outline the principles of using monoclonal antibodies in the diagnosis of disease and in the treatment of disease
- ☐☐☐ describe the differences between **active immunity** and **passive immunity** and between **natural immunity** and **artificial immunity**
- ☐☐☐ explain that **vaccines** contain antigens that stimulate immune responses to provide long-term immunity
- ☐☐☐ explain how vaccination programmes can help to control the spread of infectious diseases

12. Energy and respiration 能量与呼吸作用

12.1 Energy 能量

- ☐☐☐ outline the need for energy in living organisms, as illustrated by active transport, movement and anabolic reactions, such as those occurring in DNA replication and protein synthesis
- ☐☐☐ describe the features of **ATP** that make it suitable as the **universal energy currency**
- ☐☐☐ state that ATP is synthesised by: • transfer of phosphate in **substrate-linked reactions** • **chemiosmosis** in membranes of mitochondria and chloroplasts
- ☐☐☐ explain the relative energy values of carbohydrates, lipids and proteins as **respiratory substrates**
- ☐☐☐ state that the **respiratory quotient (RQ)** is the ratio of the number of molecules of carbon dioxide produced to the number of molecules of oxygen taken in, as a result of respiration
- ☐☐☐ calculate RQ values of different respiratory substrates from equations for respiration
- ☐☐☐ describe and carry out investigations, using simple **respirometers**, to determine the RQ of germinating seeds or small invertebrates (e.g. blowfly larvae)

12.2 Respiration 呼吸作用

- ☐☐☐ State where each of the four stages in **aerobic respiration** occurs in eukaryotic cells: • **glycolysis** in the cytoplasm • **link reaction** in the mitochondrial matrix • **Krebs cycle** in the mitochondrial matrix • **oxidative phosphorylation** on the inner membrane of mitochondria
- ☐☐☐ outline glycolysis as phosphorylation of glucose and the subsequent splitting of fructose 1,6-bisphosphate (6C) into two **triose phosphate** molecules (3C), which are then further oxidised to **pyruvate** (3C), with the production of ATP and reduced NAD
- ☐☐☐ explain that, when oxygen is available, pyruvate enters mitochondria to take part in the link reaction
- ☐☐☐ describe the link reaction, including the role of **coenzyme A** in the transfer of **acetyl** (2C) groups
- ☐☐☐ outline the Krebs cycle, explaining that **oxaloacetate** (4C) acts as an acceptor of the 2C fragment from acetyl coenzyme A to form **citrate** (6C), which is converted back to oxaloacetate in a series of small steps
- ☐☐☐ explain that reactions in the Krebs cycle involve **decarboxylation** and **dehydrogenation** and the reduction of the coenzymes NAD and FAD
- ☐☐☐ describe the role of NAD and FAD in transferring hydrogen to carriers in the inner mitochondrial membrane
- ☐☐☐ explain that during oxidative phosphorylation: • hydrogen atoms split into protons and energetic electrons • energetic electrons release energy as they pass through the **electron transport chain** (details of carriers are not expected) • the released energy is used to transfer protons

across the inner mitochondrial membrane • protons return to the mitochondrial matrix by facilitated diffusion through ATP synthase, providing energy for ATP synthesis (details of ATP synthase are not expected) • oxygen acts as the final electron acceptor to form water

- ☐☐☐ describe the relationship between the structure and function of mitochondria using diagrams and electron micrographs
- ☐☐☐ outline respiration in **anaerobic conditions** in mammals (**lactate fermentation**) and in yeast cells (**ethanol fermentation**)
- ☐☐☐ explain why the energy yield from respiration in aerobic conditions is much greater than the energy yield from respiration in anaerobic conditions (a detailed account of the total yield of ATP from the aerobic respiration of glucose is not expected)
- ☐☐☐ explain how rice is adapted to grow with its roots submerged in water, limited to the development of **aerenchyma** in roots, ethanol fermentation in roots and faster growth of stems
- ☐☐☐ describe and carry out investigations using **redox indicators**, including **DCPIP** and **methylene blue**, to determine the effects of temperature and substrate concentration on the rate of respiration of yeast
- ☐☐☐ describe and carry out investigations using simple respirometers to determine the effect of temperature on the rate of respiration

13. Photosynthesis 光合作用

13.1 Photosynthesis as an energy transfer process 作为能量转移过程的光合作用

- ☐☐☐ describe the relationship between the structure of **chloroplasts**, as shown in diagrams and electron micrographs, and their function
- ☐☐☐ explain that energy transferred as ATP and reduced NADP from the **light-dependent stage** is used during the **light-independent stage** (**Calvin cycle**) of photosynthesis to produce complex organic molecules
- ☐☐☐ state that within a chloroplast, the **thylakoids** (thylakoid membranes and thylakoid spaces), which occur in stacks called **grana**, are the site of the light-dependent stage and the **stroma** is the site of the light-independent stage
- ☐☐☐ describe the role of **chloroplast pigments** (**chlorophyll a**, **chlorophyll b**, **carotene** and **xanthophyll**) in light absorption in thylakoids
- ☐☐☐ interpret **absorption spectra** of chloroplast pigments and **action spectra** for photosynthesis
- ☐☐☐ describe and use **chromatography** to separate and identify chloroplast pigments (reference should be made to R_f values in identification of chloroplast pigments)
- ☐☐☐ state that **cyclic photophosphorylation** and **non-cyclic photophosphorylation** occur during the light-dependent stage of photosynthesis
- ☐☐☐ explain that in cyclic photophosphorylation: • only photosystem I (PSI) is involved • photoactivation of chlorophyll occurs • ATP is synthesised
- ☐☐☐ explain that in non-cyclic photophosphorylation: • **photosystem I (PSI)** and **photosystem II (PSII)** are both involved • photoactivation of chlorophyll occurs • the **oxygen-evolving complex** catalyses the **photolysis** of water • ATP and reduced NADP are synthesised
- ☐☐☐ explain that during photophosphorylation: • energetic electrons release energy as they pass through the electron transport chain (details of carriers are not expected) • the released energy is used to transfer protons across the thylakoid membrane • protons return to the stroma from the thylakoid space by facilitated diffusion through ATP synthase, providing energy for ATP synthesis (details of ATP synthase are not expected)
- ☐☐☐ outline the three main stages of the Calvin cycle: • **rubisco** catalyses the fixation of carbon dioxide by combination with a molecule of **ribulose bisphosphate (RuBP)**, a 5C compound, to yield two molecules of **glycerate 3-phosphate (GP)**, a 3C compound • GP is reduced to triose phosphate (TP) in reactions involving reduced NADP and ATP • RuBP is regenerated

from TP in reactions that use ATP

☐☐☐ state that Calvin cycle intermediates are used to produce other molecules, limited to GP to produce some amino acids and TP to produce carbohydrates, lipids and amino acids

13.2 Investigation of limiting factors 限制因素的探究

☐☐☐ state that **light intensity**, **carbon dioxide concentration** and **temperature** are examples of **limiting factors** of photosynthesis

☐☐☐ explain the effects of changes in light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis

☐☐☐ describe and carry out investigations using **redox indicators**, including **DCPIP** and **methylene blue**, and a suspension of chloroplasts to determine the effects of light intensity and light wavelength on the rate of photosynthesis

☐☐☐ describe and carry out investigations using whole plants, including aquatic plants, to determine the effects of light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis

14. Homeostasis 稳态

14.1 Homeostasis in mammals 哺乳动物的稳态

☐☐☐ explain what is meant by **homeostasis** and the importance of homeostasis in mammals

☐☐☐ explain the principles of homeostasis in terms of internal and external stimuli, **receptors**, coordination systems (**nervous system** and **endocrine system**), **effectors** (muscles and glands) and **negative feedback**

☐☐☐ state that **urea** is produced in the liver from the **deamination** of excess amino acids

☐☐☐ describe the structure of the human **kidney**, limited to: • fibrous capsule • **cortex** • **medulla** • **renal pelvis** • **ureter** • branches of the renal artery and renal vein

☐☐☐ Identify, in diagrams, photomicrographs and electron micrographs, the parts of a **nephron** and its associated blood vessels and structures, limited to: • **glomerulus** • **Bowman's capsule** • **proximal convoluted tubule** • **loop of Henle** • **distal convoluted tubule** • **collecting duct**

☐☐☐ describe and explain the formation of urine in the nephron, limited to: • the formation of **glomerular filtrate** by **ultrafiltration** in the Bowman's capsule • **selective reabsorption** in the proximal convoluted tubule

☐☐☐ relate the detailed structure of the Bowman's capsule and proximal convoluted tubule to their functions in the formation of urine

☐☐☐ describe the roles of the **hypothalamus**, **posterior pituitary gland**, **antidiuretic hormone (ADH)**, **aquaporins** and collecting ducts in **osmoregulation**

☐☐☐ describe the principles of **cell signalling** using the example of the control of **blood glucose concentration** by **glucagon**, limited to: • binding of hormone to cell surface receptor causing conformational change • activation of G-protein leading to stimulation of adenylyl cyclase • formation of the **second messenger**, **cyclic AMP (cAMP)** • activation of protein kinase A by cAMP leading to initiation of an enzyme cascade • amplification of the signal through the enzyme cascade as a result of activation of more and more enzymes by phosphorylation • cellular response in which the final enzyme in the pathway is activated, catalysing the breakdown of glycogen

☐☐☐ explain how negative feedback control mechanisms regulate blood glucose concentration, with reference to the effects of insulin on muscle cells and liver cells and the effect of glucagon on liver cells

☐☐☐ explain the principles of operation of test strips and **biosensors** for measuring the concentration of glucose in blood and urine, with reference to **glucose oxidase** and **peroxidase** enzymes

14.2 Homeostasis in plants 植物的稳态

- ☐☐☐ explain that **stomata** respond to changes in environmental conditions by opening and closing and that regulation of **stomatal aperture** balances the need for carbon dioxide uptake by diffusion with the need to minimise water loss by **transpiration**
- ☐☐☐ explain that stomata have daily rhythms of opening and closing
- ☐☐☐ describe the structure and function of **guard cells** and explain the mechanism by which they open and close stomata
- ☐☐☐ describe the role of **abscisic acid** in the closure of stomata during times of water stress, including the role of **calcium ions** as a **second messenger**

15. Control and coordination 调节与协调

15.1 Control and coordination in mammals 哺乳动物的调节与协调

- ☐☐☐ describe the features of the **endocrine system** with reference to the hormones ADH, glucagon and insulin (see 14.1.8, 14.1.9 and 14.1.10)
- ☐☐☐ compare the features of the nervous system and the endocrine system
- ☐☐☐ describe the structure and function of a **sensory neurone** and a **motor neurone** and state that **intermediate neurones** connect sensory neurones and motor neurones
- ☐☐☐ outline the role of **sensory receptor cells** in detecting **stimuli** and stimulating the transmission of impulses in sensory neurones
- ☐☐☐ describe the sequence of events that results in an **action potential** in a sensory neurone, using a **chemoreceptor** cell in a human taste bud as an example
- ☐☐☐ describe and explain changes to the **membrane potential** of neurones, including: • how the **resting potential** is maintained • the events that occur during an action potential • how the resting potential is restored during the **refractory period**
- ☐☐☐ describe and explain the rapid transmission of an impulse in a **myelinated neurone** with reference to **saltatory conduction**
- ☐☐☐ explain the importance of the refractory period in determining the frequency of impulses
- ☐☐☐ describe the structure of a **cholinergic synapse** and explain how it functions, including the role of **calcium ions**
- ☐☐☐ describe the roles of **neuromuscular junctions**, the **T-tubule system** and **sarcoplasmic reticulum** in stimulating contraction in **striated muscle**
- ☐☐☐ describe the ultrastructure of striated muscle with reference to sarcomere structure using electron micrographs and diagrams
- ☐☐☐ explain the **sliding filament model** of muscular contraction including the roles of **troponin**, **tropomyosin**, calcium ions and ATP

15.2 Control and coordination in plants 植物的调节与协调

- ☐☐☐ describe the rapid response of the **Venus fly trap** to stimulation of hairs on the lobes of modified leaves and explain how the closure of the trap is achieved
- ☐☐☐ explain the role of **auxin** in elongation growth by stimulating **proton pumping** to acidify cell walls
- ☐☐☐ describe the role of **gibberellin** in the germination of barley (see 16.3.4)

16. Inheritance 遗传

16.1 Passage of information from parents to offspring 亲代向子代传递遗传信息

- ☐☐☐ explain the meanings of the terms **haploid (n)** and **diploid (2n)**
- ☐☐☐ explain what is meant by **homologous pairs** of chromosomes
- ☐☐☐ explain the need for a **reduction division** during **meiosis** in the production of **gametes**
- ☐☐☐ describe the behaviour of chromosomes in plant and animal cells during meiosis and the associated behaviour of the nuclear envelope, the cell surface membrane and the spindle (names of the main stages of meiosis, but not the sub-divisions of prophase I, are expected: prophase I, metaphase I, anaphase I, telophase I, prophase II, metaphase II, anaphase II and telophase II)
- ☐☐☐ interpret photomicrographs and diagrams of cells in different stages of meiosis and identify the main stages of meiosis
- ☐☐☐ explain that **crossing over** and **random orientation** (**independent assortment**) of pairs of homologous chromosomes and sister chromatids during meiosis produces genetically different gametes
- ☐☐☐ explain that the random fusion of gametes at **fertilisation** produces genetically different individuals

16.2 The roles of genes in determining the phenotype 基因在决定表现型中的作用

- ☐☐☐ explain the terms **gene**, **locus**, **allele**, **dominant**, **recessive**, **codominant**, **linkage**, **test cross**, F1, F2, **phenotype**, **genotype**, **homozygous** and **heterozygous**
- ☐☐☐ interpret and construct genetic diagrams, including **Punnett squares**, to explain and predict the results of **monohybrid crosses** and **dihybrid crosses** that involve dominance, **codominance**, **multiple alleles** and **sex linkage**
- ☐☐☐ interpret and construct genetic diagrams, including Punnett squares, to explain and predict the results of dihybrid crosses that involve **autosomal linkage** and **epistasis** (knowledge of the expected ratios for different types of epistasis is not expected)
- ☐☐☐ interpret and construct genetic diagrams, including Punnett squares, to explain and predict the results of test crosses
- ☐☐☐ use the **chi-squared test** to test the significance of differences between observed and expected results (the formula for the chi-squared test will be provided, as shown in the Mathematical requirements)
- ☐☐☐ explain the relationship between genes, proteins and phenotype with respect to the: • TYR gene, tyrosinase and **albinism** • HBB gene, haemoglobin and **sickle cell anaemia** • F8 gene, factor VIII and **haemophilia** • HTT gene, huntingtin and **Huntington's disease**
- ☐☐☐ explain the role of **gibberellin** in stem elongation including the role of the dominant allele, Le, that codes for a functional enzyme in the gibberellin synthesis pathway, and the recessive allele, le, that codes for a non-functional enzyme

16.3 Gene control 基因调控

- ☐☐☐ describe the differences between **structural genes** and **regulatory genes** and the differences between **repressible enzymes** and **inducible enzymes**
- ☐☐☐ explain genetic control of protein production in a prokaryote using the **lac operon** (knowledge of the role of cAMP is not expected)
- ☐☐☐ state that **transcription factors** are proteins that bind to DNA and are involved in the control of gene expression in eukaryotes by decreasing or increasing the rate of transcription
- ☐☐☐ explain how **gibberellin** activates genes by causing the breakdown of **DELLA protein** repressors, which normally inhibit factors that promote transcription

17. Selection and evolution 选择与进化

17.1 Variation 变异

- ☐☐☐ explain, with examples, that **phenotypic variation** is due to **genetic factors** or **environmental factors** or a combination of genetic and environmental factors
- ☐☐☐ explain what is meant by **discontinuous variation** and **continuous variation**
- ☐☐☐ explain the genetic basis of discontinuous variation and continuous variation
- ☐☐☐ use the **t-test** to compare the means of two different samples (the formula for the t-test will be provided, as shown in the Mathematical requirements)

17.2 Natural and artificial selection 自然选择与人工选择

- ☐☐☐ explain that **natural selection** occurs because populations have the capacity to produce many offspring that compete for resources; in the 'struggle for existence', individuals that are best adapted are most likely to survive to reproduce and pass on their alleles to the next generation
- ☐☐☐ explain how environmental factors can act as **stabilising**, **disruptive** and **directional** forces of natural selection
- ☐☐☐ explain how selection, the **founder effect** and **genetic drift**, including the **bottleneck effect**, may affect **allele frequencies** in populations
- ☐☐☐ outline how bacteria become resistant to antibiotics as an example of natural selection
- ☐☐☐ use the **Hardy–Weinberg principle** to calculate allele and genotype frequencies in populations and state the conditions when this principle can be applied (the two equations for the Hardy–Weinberg principle will be provided, as shown in the Mathematical requirements)
- ☐☐☐ describe the principles of **selective breeding** (**artificial selection**)
- ☐☐☐ outline the following examples of selective breeding: • the introduction of disease resistance to varieties of wheat and rice • inbreeding and hybridisation to produce vigorous, uniform varieties of maize • improving the milk yield of dairy cattle

17.3 Evolution 进化

- ☐☐☐ outline the theory of **evolution** as a process leading to the formation of new **species** from pre-existing species over time, as a result of changes to **gene pools** from generation to generation
- ☐☐☐ discuss how **DNA sequence data** can show evolutionary relationships between species
- ☐☐☐ explain how **speciation** may occur as a result of **genetic isolation** by: • geographical separation (**allopatric speciation**) • ecological and behavioural separation (**sympatric speciation**)

18. Classification, biodiversity and conservation 分类、生物多样性与保护

18.1 Classification 分类

- ☐☐☐ discuss the meaning of the term **species**, limited to the **biological species concept**, morphological species concept and ecological species concept
- ☐☐☐ describe the classification of organisms into **three domains**: **Archaea**, **Bacteria** and **Eukarya**
- ☐☐☐ state that Archaea and Bacteria are **prokaryotes** and that there are differences between them, limited to differences in membrane lipids, ribosomal RNA and composition of cell walls
- ☐☐☐ describe the classification of organisms in the Eukarya domain into the **taxonomic hierarchy** of **kingdom**, **phylum**, **class**, **order**, **family**, **genus** and **species**
- ☐☐☐ outline the characteristic features of the kingdoms **Protoctista**, **Fungi**, **Plantae** and **Animalia**
- ☐☐☐ outline how viruses are classified, limited to the type of nucleic acid (RNA or DNA) and whether

this is single stranded or double stranded

18.2 Biodiversity 生物多样性

- ☐☐☐ define the terms **ecosystem** and **niche**
- ☐☐☐ explain that **biodiversity** can be assessed at different levels, including: the number and range of different ecosystems and habitats, the number of species and their relative abundance, the genetic variation within each species
- ☐☐☐ explain the importance of **random sampling** in determining the biodiversity of an area
- ☐☐☐ describe and use suitable methods to assess the distribution and abundance of organisms in an area, limited to **frame quadrats**, **line transects**, **belt transects** and **mark-release-recapture** using the **Lincoln index** (the formula for the Lincoln index will be provided, as shown in the Mathematical requirements)
- ☐☐☐ use **Spearman's rank correlation** and **Pearson's linear correlation** to analyse the relationships between two variables, including how **biotic** and **abiotic** factors affect the distribution and abundance of species (the formulae for these correlations will be provided, as shown in the Mathematical requirements)
- ☐☐☐ use **Simpson's index of diversity** (D) to calculate the biodiversity of an area, and state the significance of different values of D (the formula for Simpson's index of diversity will be provided, as shown in the Mathematical requirements)

18.3 Conservation 保护

- ☐☐☐ explain why populations and species can become **extinct** as a result of: • **climate change** • **competition** • hunting by humans • degradation and loss of habitats
- ☐☐☐ outline reasons for the need to maintain **biodiversity**
- ☐☐☐ outline the roles of zoos, botanic gardens, conserved areas (including national parks and marine parks), 'frozen zoos' and **seed banks**, in the conservation of **endangered species**
- ☐☐☐ describe methods of assisted reproduction used in the conservation of endangered mammals, limited to **IVF**, **embryo transfer** and **surrogacy**
- ☐☐☐ explain reasons for controlling **invasive alien species**
- ☐☐☐ outline the role in conservation of the **International Union for Conservation of Nature (IUCN)** and the **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**

19. Genetic technology 遗传技术

19.1 Principles of genetic technology 遗传技术的原理

- ☐☐☐ define the term **recombinant DNA**
- ☐☐☐ explain that **genetic engineering** is the deliberate manipulation of genetic material to modify specific characteristics of an organism and that this may involve transferring a gene into an organism so that the gene is expressed
- ☐☐☐ explain that genes to be transferred into an organism may be: • extracted from the DNA of a donor organism • synthesised from the mRNA of a donor organism • synthesised chemically from nucleotides
- ☐☐☐ explain the roles of **restriction endonucleases**, **DNA ligase**, **plasmids**, **DNA polymerase** and **reverse transcriptase** in the transfer of a gene into an organism
- ☐☐☐ explain why a **promoter** may have to be transferred into an organism as well as the desired gene
- ☐☐☐ explain how gene expression may be confirmed by the use of **marker genes** coding for fluorescent products

- ☐☐☐ explain that **gene editing** is a form of genetic engineering involving the insertion, deletion or replacement of DNA at specific sites in the genome
- ☐☐☐ describe and explain the steps involved in the **polymerase chain reaction (PCR)** to clone and amplify DNA, including the role of **Taq polymerase**
- ☐☐☐ describe and explain how **gel electrophoresis** is used to separate DNA fragments of different lengths
- ☐☐☐ outline how **microarrays** are used in the analysis of genomes and in detecting mRNA in studies of gene expression
- ☐☐☐ outline the benefits of using databases that provide information about nucleotide sequences of genes and genomes, and amino acid sequences of proteins and protein structures

19.2 Genetic technology applied to medicine 遗传技术在医学中的应用

- ☐☐☐ explain the advantages of using **recombinant human proteins** to treat disease, using the examples **insulin**, **factor VIII** and **adenosine deaminase**
- ☐☐☐ outline the advantages of **genetic screening**, using the examples of **breast cancer** (BRCA1 and BRCA2), **Huntington's disease** and **cystic fibrosis**
- ☐☐☐ outline how genetic diseases can be treated with **gene therapy**, using the examples **severe combined immunodeficiency (SCID)** and inherited eye diseases
- ☐☐☐ discuss the social and ethical considerations of using genetic screening and gene therapy in medicine

19.3 Genetically modified organisms in agriculture 农业中的转基因生物

- ☐☐☐ explain that **genetic engineering** may help to solve the global demand for food by improving the quality and productivity of farmed animals and crop plants, using the examples of **GM salmon**, **herbicide resistance** in soybean and **insect resistance** in cotton
- ☐☐☐ discuss the ethical and social implications of using **genetically modified organisms (GMOs)** in food production