Research
Based
Curricula

DNA AND ANTICANCER DRUG DISCOVERY

Key Stage 3

Science

2021

BROUGHT TO YOU BY RBC ACCESS ED

For Teachers
RBC Guide

Learner aims

The Research-Based Curriculum aims to support student attainment and progression by providing classroom resources about cutting-edge research at local universities. The resources are designed to:

- ✓ promote intellectual curiosity in all KS3 students
- ✓ stretch and challenge students to think about content that may be beyond the confines of the curriculum
- ✓ develop core academic skills, including critical thinking, metacognition, and written and verbal communication
- ✓ Encourage students to view these subjects as engaging, worthwhile and inspiring for continued and further study

Content

The programme represents a unique collaboration between universities and schools. Trained by AccessEd, PhD Researchers use their subject expertise to create rich resources that help bring new discoveries and debates to students.

The Research-Based Curriculum packs offer four units suitable for KS3 students. The lessons (units) span a range of exciting and interdisciplinary topics related to English, Maths and Science. Each pack includes four hours of teaching and practical, student-led activity content, supported by a student pack and teacher notes. All packs are available online and free of charge for teachers at select schools.

Each Subject Pack contains:

1. Four chapters that function as subject 'lessons'
2. Questions and practical activities to check and reinforce understanding
3. Challenge activities and extra reading
4. Study skills, tips and guidance at the back
5. Model answers pack (this document)

For Teachers
Using the RBC packs

Suggested school use

These resources are designed to be used flexibly by teachers. They can be completed by students individually or in groups, inside or outside the classroom. In order to achieve the best possible outcomes for students, it is recommended that these packs are delivered with teacher support.

Delivery options

Classroom discussion and curriculum support

These curriculum-linked packs and their activities, as well as the Final Reflection, can be great structures for in-class discussion or debates, if a final written Reflection isn't possible. They are also ideal as an alternative for a written assignment. These packs supplement curriculum learning with additional case studies and extra-curricula working examples.

Homework activities and parent/carer-led time

Questions can be set as homework activity for students, either following an RBC chapter delivered during a lesson, or as an independent reading and study task. Questions can also be set for parents and carers to lead with their children.

Lunch Club

The resources can be completed in small groups across a series of weekly lunch clubs or after-school clubs online or in person. Groups can reflect on their learning by presenting a talk or poster on the subject matter at the end of the course.

Research challenge

The resources can be used to ignite curiosity in new topics and encourage independent work. Schools could hold a research challenge across a class or year group. Pupils could choose their own difficulty level and final presentation format – essay, presentation, video, etc., and submit individually or in small groups, with a final celebration event.

Transition project

Resource packs can function as 'transition' projects over the summer, serving as an introduction to the next level of study between KS3 and KS4. Students could present their reflections on the experience in a journal.

Unit One
Model Answers

Answers

1. Nucleic acids are polymers – they are polynucleotides or poly(nucleotides), consisting of many repeating nucleotide monomers.

2. Phosphate group, (deoxy)ribose sugar and a base.

3. Phosphodiester bonds (a covalent bond involving phosphate sharing electrons) spanning from the fifth carbon (5') of one nucleotide to the third carbon (3') of the adjacent nucleotide.

4. RNA contains ribose instead of deoxyribose. DNA contains the bases cytosine (C), thymine (T), adenine (A) and guanine (G). RNA contains uracil (U) instead of thymine.

5. Deoxyribose lacks an oxygen (O), hence the name 'deoxy'ribose and vice versa.

6. Pyrimidines collectively refer to the bases cytosine and thymine. Purines collectively refer to the bases adenine and guanine. Pyrimidines are one-ring structures and

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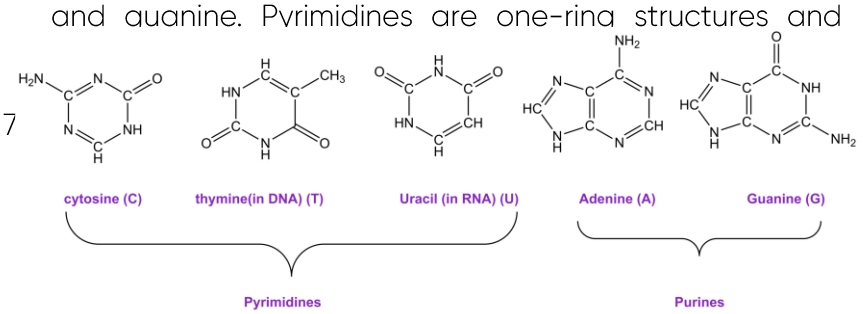
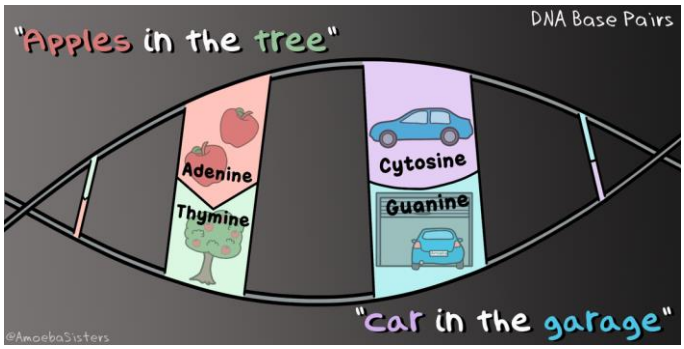


8. Nucleus

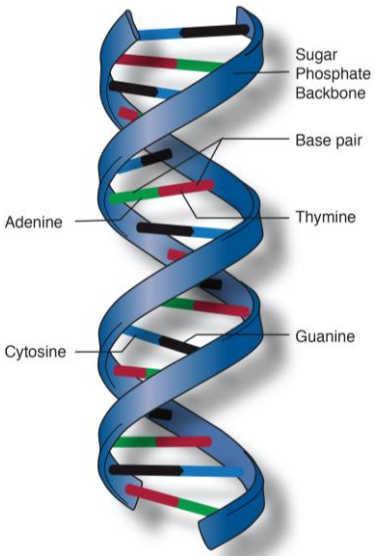
Unit Two
Model Answers

Answers

1. Example mnemonic



2.



3. Major groove – 12 Å or 0.0000012 cm

Minor groove – 6 Å or 0.00000006 cm

4. The 'central dogma of life or molecular biology' refers to the process of transcription (of DNA into RNA), translation (of RNA into amino acid chains), and replication (duplication of DNA).

5. DNA was discovered in 1953 by the American scientist, James Watson, and the British scientist, Francis Crick. Another British scientist, Rosalind Franklin, also contributed to the discovery of DNA. She should have shared in the Nobel Prize, but sadly died of ovarian cancer, four years before the prize was awarded.

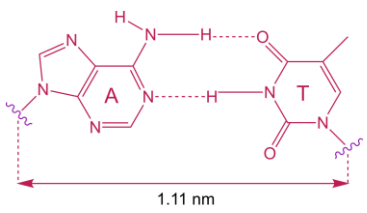
Unit Two
Model Answers

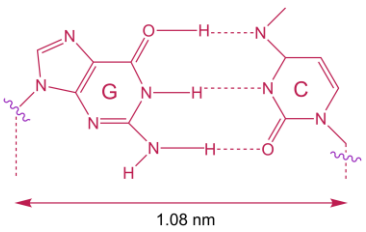
Answers

6. The primary structure of a molecule is the first level of structure, and in DNA it is the arrangement and order of nucleotide monomers into a single polymer strand. The secondary structure of DNA is formed when two strands of DNA are linked due to interactions between the bases, which stick out to the side of the strands.

7. Purine bases always hydrogen bond with pyrimidine bases, and more specifically, adenine bonds to thymine to form an A-T sequence, and guanine with cytosine to form a G-C sequence. These are called base pairs and the specificity of the pairing is referred to as complementary base pairing.

8. Purine bases always hydrogen bond with pyrimidine bases. The complementary base pairs between two DNA strands form a ladder-like structure where the sugar–phosphate strands form the parallel sides (or backbone) of the 'ladder' and the pairs of complementary bases form the 'rungs'.





Unit Three Model Answers

Answers

1. Cisplatin was discovered unexpectedly. Another major anticancer drug discovered unexpectedly was nitrogen mustard, which lead to the discovery of a type of chemotherapeutic drugs called alkylating agents. Statistics can be included to support argument e.g. 24% of all drugs or 35% of all anticancer drugs were discovered unexpectedly.

2. Reversible and Irreversible

3. Electrostatic interaction – Spermidine and Spermine

   Groove binding – Netropsin and Distamycin A

   Intercalation – Ethidium Bromide

4. Cis-diamminedichloroplatinum (II) (CDDP), or more commonly, cisplatin

5. Ethidium Bromide

6. DNA binding molecules have significance because they can interfere with the processes of replication and transcription, and as such offer potential treatments for cancer. For example, cisplatin binds together strands of DNA and prevents replication of DNA, thus tumour cells can not divide and multiply.

Unit Four
Model Answers

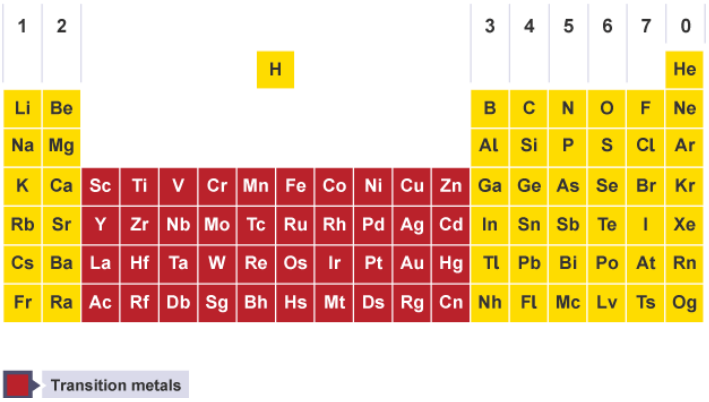
Answers

1. Example arguments

For: Aid in the discovery of a potentially revolutionary/life-saving drug.

Against: The new drug may cause aggressive systemic toxicity similar to cisplatin, or other harmful side effects.

2. The period table can be divided into the Main Group, Transition Metals and Inner Transition Metals. The first 20 elements are: Hydrogen (H), Helium (He), Lithium (Li), Berylium (Be), Boron (B), Carbon (C), Nitrogen (N), Oxygen (O), Fluorine (F), Neon (Ne), Sodium (Na), Magnesium (Mg), Aluminium (Al), Silicon (Si), Phosphorous (P), Sulphur (S), Chlorine (Cl), Argon (Ar), Potassium (K) and Calcium (Ca).



3. The transition metals are metallic elements. They are 'd-block' elements, having a partially-filled d subshell. Compounds of transition metals are usually coloured, and since transition metals exhibit various oxidation states (loss of electrons), they come in a wide range of appealing colours like red, yellow, orange, etc.

4. The interactions of transition metal complexes with DNA have led to the design of new drugs and theranostics, and imaging agents. Such transition metals often used for the construction of therapeutics are collectively known as the d^6-platinum metal group, and include ruthenium, rhodium, palladium, osmium, iridium and platinum.

Unit Four
Model Answers

Answers

5. Cancerous

6. NAMI-A and KP1019

7. Ruthenium, being a Group 8 transition-metal, was originally studied to reduce the systemic toxicity of cisplatin. Ruthenium(II)-based drugs exhibit effects in platinum-resistant cells. Ruthenium(II) anti-cancer agents can be administered in their less active forms, allowing them to be targeted to cancerous areas.

8. Iron (Fe), Osmium (Os) and Hassium (Hs).

9. Iridium(III) complexes have been used for the construction of luminescent DNA spectroscopic probes. Since iridium (3+) has a higher positive charge than ruthenium (2+), it is anticipated that iridium(III) complexes will likely display a stronger binding interaction with the phosphate anionic groups of DNA than ruthenium complexes.

10. Studies into the use of iridium (III) complexes as anticancer therapeutics are still relatively newer than their ruthenium(II) counterparts. Presently, no iridium(III) complex has made it to clinical trials.

Final Reflection Activity Further Guidance

The student's poster or PowerPoint presentation could contain the following information under each subheading:

1. What cancer is and how DNA is involved.

- Cancer definition and difference between benign and malignant
- DNA damage repair in normal cell vs cancer cell

2. How the metal complexes interact with DNA and what effect this has.

- Transition metals
- Ruthenium(II) and Iridium(III) anticancer drug as examples

- DNA binding mechanisms - irreversible and reversible binding

3. Examples of metal-based anticancer drugs, and how each works.

- Cisplatin – reversible binding
- Spermidine and Spermine – electrostatic interaction
- Netropsin and Distamycin A – groove binding
- Ethidium Bromide - intercalation

4. What future developments might there be in metal-based anticancer treatments.

- Need for future developments – drawbacks of existing drugs such as cisplatin
- How new drugs are tested – clinical trials
- Advantages of ruthenium(II) and Iridium (III) anticancer drugs

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