The ‘Ice Age’ was a series of advances and retreats of the icecaps. It lasted from 1.7 million years to 10,000 years BP.

Most of Britain was glaciated as far south as the Severn-Thames line.
These occur at high altitudes, latitudes nearer the poles and often on the colder, north-facing slopes.

**formation of a glacier**

Glaciers form in areas of permanent snow called **snowfields**.
As more snow falls the pressure makes the earlier snowflakes melt.

Repeated melting and re-freezing forms granules called firn or névé.

Further compression forms larger crystals of glacial ice.

It can take 30 to 40 years for snow to form dense glacial ice.

It now moves downslope under its own weight.
Despite being hard and solid, glacier ice flows because of:

- **internal deformation** - individual ice crystals within a glacier deform and slide across one another.

- **basal sliding** - meltwater at the base of the glacier lubricates the ice causing it to slide.
valley glacier
Zone of accumulation
This is where the snow collects, turns into ice and forms features like cirques, arêtes and pyramidal peaks. The rocks above the glacier undergo frost shattering.

Zone of flow
The ice moves under gravity. It erodes through abrasion and plucking. Glacial troughs, hanging valleys, waterfalls and lakes are formed in this zone.

Zone of wasting (melting and evaporation)
This zone contains the terminal moraine ridge and outwash plain. It occurs at the snout of the glacier.
A glacier is a system with *inputs* and *outputs*.

**ZONE of ACCUMULATION**
- mainly inputs
- precipitation
- avalanches

**ZONE of WASTING**
- mainly outputs
- evaporation
- icebergs
- meltwater
Ice erodes by:

1. Freeze Thaw (Frost Shattering)
   Water in cracks in the rock freezes and expands. After many cycles of freezing and thawing lumps of rock are broken off.

2. Plucking
   Glacier ice freezes into cracks in rocks and when the glacier moves it pulls out chunks to leave a jagged surface.

3. Abrasion
   Rocks stuck in the ice grind away the bedrock under the glacier.
Water expands when it freezes

Water from melted snow collects in cracks and crevices in rocks above glaciers.

- At night temperatures drop below freezing and the water changes into ice.
- Water expands when frozen and so exerts pressure on the sides of the crack.
- Eventually the rock shatters.
- Sharp, angular pieces of rock are formed called scree.

Scree - rock fragments broken off by freeze thaw (frost shattering)
Glacial ice melts due to friction as it goes over an obstacle like a rock mass.

This water will almost instantly refreeze because of the overlying pressure of the ice.

It re-freezes into the cracks and crevices and as the glacier moves loose pieces of rock are pulled or torn out.
This erosion process occurs when pieces of rock debris embedded in the ice wear away the rocks on the valley floor and sides.
The rock is scratched, polished, smoothed and eventually worn away by the scouring action. The pieces of rock also become smaller through this rubbing action.
Striations are scratches made on the existing surface by rocks that are embedded in the bottom of the glacier as it moves forward.
Freeze-thaw is a WEATHERING process. Plucking and abrasion are processes of EROSION.

1. Explain the difference between the processes of WEATHERING and EROSION.
2. Explain each of the three processes using diagrams and notes.
Snow collects in hollows, especially on the less sunny north and east facing slopes, turns to glacial ice and moves downwards under the force of gravity. Rocks are plucked out and the hollow is widened to become a **cirque or corrie**. A corrie is a deep, rounded hollow with a steep head or back wall.
formation of a corrie

- Sharp ridges of bare rock
- Smaller accumulations of snow
- Large Snow patches with ice underneath
a) snow collects in hollows  
b) snow compacts to ice  
c) ice moves under gravity, lubricated by meltwater  
d) ice rotates to lip  
e) abrasion deepens corrie  
f) plucking steepens back and sides  
g) corrie lochan (tarn) may fill hollow.
Copy the diagram showing a corrie after glaciation.

Label it to show:
- corrie
- headwall
- lochan (tarn)
- lip
- scree
corrie and tarn

Position photograph taken from
Once the glacier retreats, the cirque may be filled with water. A small, generally circular loch is formed. This is known as a tarn or corrie lochan.
1. Plucking: removes huge blocks from back wall.
2. Abrasion: sharp rocks embedded in ice erode the floor.
3. Rotation: the corrie glacier slides down and round in its basin.
4. Pressure from new snow.
5. Less pressure because less snow falls here.
6. Rock lip forms because corrie glacier is sliding upwards here and not eroding much.
7. After Ice Age corrie glacier leaves a basin-shaped hollow, often with tarn or corrie lake in floor of hollow.
8. Huge valley glacier fed by several corrie glaciers.
9. After Ice Age valley glacier leaves a glacial trough and often a long, narrow ‘ribbon lake’.
11. Abrasion under valley glacier.
12. Rock bar at end of valley glacier.
13. Valley glacier thinner (farthest away from snow and ice supply, so less erosion).
An arete is a narrow, sharp-edged ridge which forms the side walls of cirques and separates different glacial valleys.
Arete = knife-edged ridge
a) three or more corries form around a peak
b) where corrie sidewalls meet they form an arête (knife edge).
c) arêtes meet to form a horn (pyramidal peak).
horn = pyramidal peak
When three or more corries erode backwards a sharp pointed pyramid shape is created. This is called a Pyramidal Peak or Horn.
1. Write a definition of each of the following terms:

**corrie**

**arête**

**horn**

**tarn**

2. Which feature goes with which letter on the diagram?
Eleven National Parks have been designated in England and Wales.

National Parks have two purposes:

- to conserve the natural beauty of the countryside
- to promote public access to the countryside.
Red Tarn
Helvellyn
Lake District
Red Tarn
Helvellyn
Lake District

Red Tarn

Map of the area with a red marker indicating Red Tarn.

Corrie and tarn
When a corrie is formed, its back and side walls are steep. When two corries form next to each other a narrow rock ridge is formed. This is often likened to a knife edge, with near vertical sides and a sharp top edge. This feature is called an *arête* or knife-edged ridge.
Striding Edge
Helvellyn
Lake District
Identify examples of glacial features on the map.
a) glacier flows in an earlier 'V' shaped valley,  
b) glacier abrades the sides and floor of the river valley,  
c) valley is greatly deepened, widened and straightened,  
d) when the ice melts the valley is 'U' shaped,  
e) it has very steep sides and a fairly flat floor,  
f) any later rivers are called 'misfit streams’ because they are far too small to have cut the valley.
Describe the main features of a glaciated U-shaped valley and its ‘misfit’ river.
Glaciers are very powerful agents of erosion: they reshape former V-shaped river valleys into wide, deep, steep-sided troughs by the processes of abrasion and plucking.
Former river spurs are truncated: their ends are cut off by the ice action to form steep, sheer cliffs.
'U' shaped valley
truncated spur

terminal moraine

valley glacier

U-shaped valley
When a glaciated valley is submerged or drowned by a rise in sea level a fiord is formed. The sea lochs of western Scotland are the best examples of fiords in the British Isles.
Vertical erosion in the main glacier is far greater than in the tributary glaciers. Valleys are not the same depth and after the glacier has retreated rivers flowing down the tributary join the main trough via a waterfall.
At the base of a waterfall alluvial fans are sometimes found as a result of deposition.
alluvium = silt deposited by a river
V-shaped valley

U-shaped valley

hanging valley

waterfall
When a glacier moves along its valley some parts are deepened more than others. When the glacier retreats the deepened sections fill with melt water and become lakes.

The English Lake district owes its character to these narrow ribbon lakes along its valley floors.
Ribbon lakes can also be formed when glacial deposits build a natural barrier across a glacial trough.
These are partly erosional, partly depositional features. The rock face facing the ice is steepened by glacial erosion. Material is deposited on the opposite side to form a tail of boulder clay.
Always align a map and a diagram before identifying features.
Identify the features marked on the diagram by matching them to the names of features listed below.

Arête; Hanging Valley; Corrie (Cirque); 'U' shaped Valley; Alluvial Fan; Pyramidal Peak; Corrie Lochan (Tarn); Misfit Stream; Ribbon Lake; Truncated Spur; Screes.
1 is a Pyramidal Peak because it has steep, triangular faces divided by sharp ridges or arêtes.

2 is an Arête, because it is a sharp ridge between corries.

3 is a Corrie or cirque, because it is an armchair shaped hollow with steep back and sides.

4 is a Corrie Lochan or Tarn, because water has gathered in the hollow in the floor of the corrie.
5 is an Alluvial Fan, because it is a fan shaped pile of rock material (alluvium) washed down by the stream.

6 is a Ribbon Lake, because it is a long narrow lake in a part of the valley cut deeper by the glacier.

7 is a Truncated Spur, because the ridge has been cut off sharply by the ice that flowed down the main valley.
8 is a Misfit Stream, because it is far too small to have cut the valley.

9 is a Hanging Valley, because the valley floor is much higher than the floor of the main valley.

10 is a 'U' Shaped Valley, because it has steep sides and a nearly flat floor. (The other side of the valley is missing in this cut-away diagram).

11 are Screes which are piles of loose rocks and boulders mainly formed by frost shattering.
Landforms of weathering

scree

corrie

tarn

arête

horn

U-shaped valley

truncated spur

hanging valley

fiord

ribbon lake

Landforms of glacial erosion

crag and tail

moraine

erratic

drumlin

outwash plain

Landforms of glacial deposition

esker

kettle

Landforms of fluvioglacial deposition
LANDFORMS of GLACIAL DEPOSITION

A lowland landscape during glaciation

Direction of ice movement

Boulders, stones, sand and clays carried along or moved by the ice

Bedrock
LANDFORMS of GLACIAL DEPOSITION

the same lowland landscape after glaciation

terminal moraine

ground moraine
glacial deposition

- lateral and medial moraine
- ground moraine
- terminal moraine
- outwash sand and gravel
- fluvio-glacial deposition
- snout
Materials carried by the glaciers are deposited in two main ways;

Glacial Deposits (unsorted) dumped from the melting ice, such as moraines and till. These are jumbled mixtures of broken rock material of many different sizes.

Fluvo-glacial deposits (sorted) washed out of the ice by meltwaters, such as eskers. These are more rounded and have been sorted by the action of the water, the heavier materials being laid down first.
Moraine is the waste material worn away and collected by the ice
It is angular in shape
Glacial deposits are poorly sorted, ie all different sizes and rock types are mixed together.
• **Lateral moraine** is found on the sides of the glacier. Scree, from frost shattering, is an important source.

• **Medial moraine** is found down the middle of the glacial surface and occurs when the inner lateral moraines of two glaciers join.

• **Ground moraine** is found at the base (bottom) of the ice. It is also called till or boulder clay.

• **Terminal moraine** is found in front of the snout of the glacier if it is stationary. It represents the maximum advance of the ice.
Boulder clay is glacial *moraine* consisting of thick clay with angular rocks. The exact composition will depend on the rocks eroded by the glacier. Boulder clay is sometimes called *till*.
moraine
moraine

ice

terminal/end moraine

moraine

dammed lake
moraine

Lateral Moraine

End Moraine
The line where the ice-sheets end is marked by a ridge of thick, unsorted glacial deposits. This is called the terminal moraine ridge.

In front of this ridge, the melt water carries fine sand, silt and clay depositing it further on. This forms an outwash plain.
erratic
Erratics are large rocks that are completely different from the type of rocks on which they rest. They were carried by the ice-sheet, sometimes for hundreds of kilometres and then deposited.
Drumlins are smooth, rounded mounds of ground moraine. The steep side faces the ice movement.

Drumlins often occur in swarms or groups.
Glacial streams are found under the ice-sheet. They are loaded with debris (sand and gravel) carried by the meltwater. As the ice-sheet retreats, the river deposits its load.
An esker is a steep-sided, long, winding ridge, made up of gravel and sand.
sand and gravel
boulder clay
depression formed when depression filled with water to form kettle lake

block of ice
outwash sand and gravel
outwash plain

- glacier
- meltwater
- sorted sands and gravels spread out to form outwash plain
- Infertile outwash often covered by bog or forest
Identify the features shown on the diagram by matching the numbers to the names given.

Esker; Terminal Moraine; Till (Ground Moraine/Boulder Clay); Outwash Plain; Drumlin; Kettle; Outwash Sands and Gravels.
1 is a Terminal Moraine. A hummocky ridge of unsorted stones, boulders and clays dumped by the glacier at the furthest point it reached

2 is a Drumlín. A long, rounded mound of till, moulded under the flowing ice. Its narrower end points in the direction that the ice was moving. They usually occur in groups (swarms)

3 is a Kettle. A water filled hollow left when a block of ice in the till or outwash melted to leave a hollow

4 is an Esker. A long, winding ridge of sands and gravels left by a stream which ran in an ice tunnel under the melting glacier
5 is Till (Ground Moraine or Boulder Clay). A mixture of broken rocks and clay plastered over the bedrock under the base of the glacier

6 is an Outwash Plain. A nearly flat expanse of sorted sands and gravels washed out of the glacier and carried beyond the terminal moraine

7 is Outwash sands and gravels. The meltwaters washed these away from the glacier, rounding off angular stones and depositing them in layers.
Glacial deposition = unsorted deposits = boulder clay

fluvioglacial deposition = sorted deposits = sands and gravels

Landforms of glacial erosion:
- crag and tail

Landforms of glacial deposition:
- moraine
- erratic
- drumlin

Landforms of fluvioglacial deposition:
- esker
- kettle
- outwash plain
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ablation</td>
<td>melting and evaporation of glacial ice at its snout</td>
</tr>
<tr>
<td>Abrasion</td>
<td>sand-papering effect that smoothes and polishes rocks</td>
</tr>
<tr>
<td>Alluvial fan</td>
<td>fan shaped deposit of silt when a river flows on to a plain</td>
</tr>
<tr>
<td>Alpine glacier</td>
<td>valley glacier</td>
</tr>
<tr>
<td>Arête</td>
<td>sharp, knife-edged ridge between two corries</td>
</tr>
<tr>
<td>Boulder clay</td>
<td>ground moraine</td>
</tr>
<tr>
<td>Cirque</td>
<td>armchair shaped hollow at the head of a glacial valley</td>
</tr>
<tr>
<td>Continental glacier</td>
<td>ice sheet</td>
</tr>
<tr>
<td>Corrie</td>
<td>cirque</td>
</tr>
<tr>
<td>Corrie lochan</td>
<td>tarn</td>
</tr>
<tr>
<td>Crag &amp; tail</td>
<td>steep rock face with a gentle slope of boulder clay</td>
</tr>
<tr>
<td>Crevasse</td>
<td>deep vertical crack formed in ice</td>
</tr>
<tr>
<td>Cwm</td>
<td>cirque</td>
</tr>
<tr>
<td>Drumlin</td>
<td>elongated mound of ground moraine</td>
</tr>
</tbody>
</table>
End moraine  terminal moraine
Erratic  rock transported by ice and deposited on a different rock surface
Esker  winding ridge of sand and gravel
Fiord  glacial trough drowned by a rise in sea level
Firn  granular ice
Fluvio-glacial  formed by meltwater flowing in or off a glacier
Freeze-thaw  weathering of rock by expansion of water in cracks when it freezes
Frost shattering  freeze-thaw
Glacial deposition  sediment left behind when a glacier melts
Glacial erosion  wearing away of rocks by abrasion and plucking
Glacial ice  ice formed when snow is compressed
Glacial transportation  movement of materials by glacial flow
Glacial trough  glaciated U-shaped valley with steep sides and a flat bottom
Glacier  mass of ice which flows by gravity
Ground moraine  material deposited at the base of a glacier
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanging valley</td>
<td>valley above the level of the main valley often with a waterfall</td>
</tr>
<tr>
<td>Headwall</td>
<td>steep back wall of a cirque</td>
</tr>
<tr>
<td>Ice sheet</td>
<td>mass of ice not limited to a valley</td>
</tr>
<tr>
<td>Horn</td>
<td>pyramidal peak</td>
</tr>
<tr>
<td>Kettle</td>
<td>small shallow lake on an outwash plain formed by blocks of ice melting.</td>
</tr>
<tr>
<td>Lateral moraine</td>
<td>moraine deposited along the sides of a valley glacier</td>
</tr>
<tr>
<td>Medial moraine</td>
<td>moraine formed when two alpine glaciers flow together</td>
</tr>
<tr>
<td>Meltwater</td>
<td>rivers formed by melting ice</td>
</tr>
<tr>
<td>Misfit river</td>
<td>winding river flowing in a valley it did not form</td>
</tr>
<tr>
<td>Moraine</td>
<td>angular, unsorted waste material transported by a glacier</td>
</tr>
<tr>
<td>Névé</td>
<td>firn</td>
</tr>
<tr>
<td>Outwash plain</td>
<td>sorted deposits of sands and gravels spread by meltwater</td>
</tr>
<tr>
<td>Plucking</td>
<td>erosional process - meltwater freezes into cracks and pulls out loose rock</td>
</tr>
<tr>
<td>Pyramidal peak</td>
<td>sharp, pointed peak formed by glacial action</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ribbon lake</td>
<td>long, narrow lake in a glacial trough</td>
</tr>
<tr>
<td>Scree</td>
<td>sharp, angular material produced by frost shattering</td>
</tr>
<tr>
<td>Sea loch</td>
<td>fiord</td>
</tr>
<tr>
<td>Snowfield</td>
<td>area of permanent snow found above the snowline</td>
</tr>
<tr>
<td>Snout</td>
<td>end of a glacier</td>
</tr>
<tr>
<td>Striations</td>
<td>scratches on the bedrock made by moraine carried in a glacier</td>
</tr>
<tr>
<td>Tarn</td>
<td>small circular lake in a cirque</td>
</tr>
<tr>
<td>Terminal moraine</td>
<td>moraine ridge deposited at the snout of a glacier</td>
</tr>
<tr>
<td>Till</td>
<td>ground moraine</td>
</tr>
<tr>
<td>Truncated spur</td>
<td>interlocking spur that has been cut-off by glacial erosion</td>
</tr>
<tr>
<td>U-shaped valley</td>
<td>glacial trough</td>
</tr>
<tr>
<td>Valley glacier</td>
<td>glacier confined to a valley</td>
</tr>
</tbody>
</table>