

# Changes in plumage in Canada goose goslings

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## Introduction

This resource pack from ASAB (Association for the Study of Animal Behaviour) focuses on the role of judgment in animal behaviour studies. It is aimed at students following GCSE Biology, AS/A2 Biology, Advanced Higher Biology and AS/A2 Psychology courses. It consists of:

- background information for teachers;
- a CD containing more than 50 images of Canada goose, *Branta canadensis*, goslings at various stages of development and images of seven of the behaviours of Canada geese;
- two differentiated keys which describe the plumage development at the various stages;
- drawings of Canada goose goslings with the diagnostic features highlighted;
- two differentiated exercises requiring students to allocate individual images to the appropriate developmental stage;
- a computer program to calculate the *Kappa* statistic, if desired; [for AS/A2 and Advanced Higher students]
- an exercise which requires students to write unambiguous descriptions of seven postures or behaviours of Canada geese; [for AS/A2 and Advanced Higher students]
- annotated images of goslings at each of the developmental stages which can be used to test the effect of training on the ability to allocate images to the correct stage; [AS/A2 Psychology students]
- descriptions of some of the pre-nesting behaviours of sandwich terns, *Sterna sandvicensis*;
- drawings of some of the pre-nesting behaviours of sandwich terns;
- an exercise which requires students to match the descriptions and the drawings of the pre-nesting behaviours of sandwich terns.

## References

- Lorenz, K.** 1991. Here Am I - Where Are You? The behaviour of the Greylag Goose. Harcourt Brace Jovanovich.
- Martin, P. & Bateson, P.** 2008. Measuring Behaviour: An introductory guide. Third Edition. Cambridge University Press.
- Ogilvie, M. & Young, S.** 1998. Wildfowl of the World. New Holland.
- Veen, J.** 1977. The Sandwich Tern: functional and causal aspects of nest distribution. Behaviour Supplement XX. Leiden.

## Website

Recording Animal Behaviour (can be downloaded from [www.mmu.myzen.co.uk](http://www.mmu.myzen.co.uk))

[On this website you will also find video clips of animal behaviour and computer programs which can be used to record behaviour.]

## Background information

### *The role of judgment in animal behaviour studies*

Researchers studying animal behaviour are presented with an ongoing stream of behaviours performed by the animal under observation. They seek to segment the stream into a smaller number of unambiguously identifiable units or behavioural elements. They may also seek to divide a population into different age classes in order to study the process of development of different behaviours and changes in their use with time. Frequently this is done on the basis of external appearance. Observers differ in their capacity to make such judgments reliably, though this may increase with practice.

This resource looks at the appearance and behaviour of two birds, the Canada goose and the sandwich tern, and mainly the former.

### *Canada geese*

Canada geese are a North American species which was introduced to England in the 17<sup>th</sup> century. Birds escaped from collections and are now found on water bodies throughout much of England and in parts of Scotland. The total British population of feral birds is more than 60,000 (Ogilvie and Young 1998) and may be as many as 90,000 individuals.

### *Appearance*

Canada geese are large birds having a length of 90-100 cm and weighing 4-5 kg. Their long black neck, white cheek patches, and brown feathering on the wings and back, make them unlikely to be confused with any other kind of goose, see Figure 1.

Figure 1 An adult Canada goose



## *Incubation, Hatching and Development*

Usually 5-6 eggs are laid but a female may lay as many as 10 or as few as 3. Like all geese the incubation period of Canada geese is long, being 28 days. Incubation is carried out solely by the female who may feed very little during this period, only leaving the nest to empty her cloaca and to drink. These periods (or 'recesses') away from the nest are very important to the development of the embryo as during this time the eggs cool slightly so that the contents of the air pocket of the egg contract slightly so that fresh air is drawn into the egg.

The goslings remain in the nest for about 24 hours after hatching, after which they leave the nest and feed under the protection of their parents. The male takes the leading role in this whilst the female feeds to replace the nutrients lost during incubation.

The goslings are dependent upon their parents for protection until they can fly at the age of 70-72 days. During this time they go through a series of stages of plumage development which are approximately related to age. Initially the plumage is entirely composed of down feathers and is quite unlike that of the adult birds. Gradually this changes into a so-called 'juvenal' plumage which becomes progressively more and more like that of adult geese.

In the key which follows the body is covered entirely in down in stages 1 and 2, feathers begin to appear amongst the down in stages 3 and 4, the first appearance of juvenal plumage is stage 5 and the fully developed, adult like, plumage is called stage 8.

## *Sandwich terns*

Unlike Canada geese which are solitary nesters with nests tens to hundreds of metres apart, sandwich terns nest in very dense colonies with nests often only 20 to 30 cm apart. Whilst Canada geese form long lasting breeding pairs which stay together throughout the winter, sandwich terns form breeding pairs each year on areas close to the nesting colony. Pair formation, nest site selection and nest defence were studied by Veen (1977) who identified and described about a dozen distinct behaviours. Together these form part of the ethogram (a detailed record of an animal's behaviour) of the species.

## *Identifying Behaviours*

In order that different behaviours can be consistently identified throughout a single study, and in later studies too, it is necessary to produce unambiguous descriptions of the behaviour. Usually these will rely upon descriptions of the relative orientation of the main axis of the body, of the head, neck and limbs, and in the appearance of crests or other adornments. In some cases these may be supplemented by drawings or photographs. One test of a good description is whether a third party can match it with an illustration of the same behaviour or posture. Good descriptions of behaviour can only be produced following close observation. Postures are easier to describe.

## The Exercises

### *Plumage development of Canada geese goslings*

This is presented in two parts with different levels of difficulty. They differ in the language used, the level of detail and the requirements of the exercise. The first is likely to be suitable for use with students following GCSE Biology courses and the second for AS/A2/Advanced Higher students of Biology and Psychology. Both exercises contain a suggestion about how the results might be analysed.

## The Simplified Key (for GCSE students)

The pictures in the 'Simple' folder are easy to allocate to stages and should be suitable for use with GCSE students. The task is straightforward, the students have to allocate the images to one of the eight stages of development. The instructions and drawings of the stages are on student sheets S1 and S2. A check sheet, S3, is provided for them to record their allocation of the images. This information is also provided below.

The students use the check sheet (S3), together with the diagrams, to allocate each of the eight pictures to the correct developmental stage. They should pay particular attention to the parts of the sentences in ***bold italic script***.

## Simplified Rank Order Test

If it is required to assess the accuracy of the allocation of pictures to the correct stage then the Spearman Rank Order test (Spearman Rank Correlation Coefficient) can be used in a simplified form. *This test can only be used if eight pictures are used.*

The steps involved are these:

Calculate the difference between each of the true stages and the allocated stages. Square each of these differences and then add them together. Divide the result by 84. Subtract this value from 1.

This gives a score between -1.00 and +1.00. Perfect agreement will give a score of +1.00 and perfect disagreement will give a score of -1.00. Scores of more than +0.74 can be considered as a reasonably accurate matching of the images and stages of growth.

**Fig 2 Stages in plumage development in Canada goose goslings (GCSE)**

## Stage 1

A very young gosling is small, round, downy and mostly yellow on the underside extending towards the head. The legs and neck are short and the neck is not distinct. Over time the yellow gradually fades and the back changes from yellow to a pale dusky (greyish) brown.



## Stage 2

A gosling is still downy and with some yellow still evident on the head and upper neck. The yellow on the body has now faded to a pale dusky brown. When viewed from the side the wings can be seen but there is no sign of feathers. The neck is distinct and the posture is more upright.



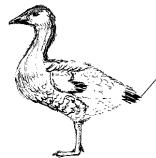
## Stage 3

When viewed from the side **wing feathers are clearly visible**. The rest of the body remains covered with a more or less uniform dusky brown down. The neck appears longer and 'serpentine' or 'snake-like'. This stage ends when the first tail feathers appear.



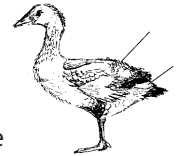
## Stage 4

This stage is reached when the **first black tail feathers become clearly visible** (about 5mm in length). The colour of the back and neck is dusky brown. Feathering can be seen on the sides, wings and belly. Later black (or very dark brown) soft downy feathering appears at the rump. This stage ends when white feathers appear on the upper surface in front of the black tail and behind the dark feathering on the rump.



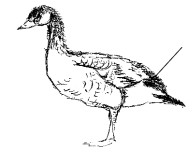
## Stage 5

The **white patch between the black tail and dark brown or black rump becomes clearly visible**. During this stage feathers can be seen on the sides, wings and belly. The overall coloration of the back and neck is still dusky brown. During stage 5 the white cheek patch becomes more visible and the neck darkens. The stage ends when the cheek patch is clearly visible and the neck is black along more or less all of its length.



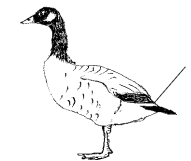
## Stage 6

This stage is reached when **the white cheek patch is clearly visible, and the head and neck are black but still carrying considerable down**. This stage ends when the folded wings have grown to just reach the back edge of the black (dark brown) rump.



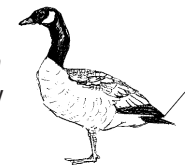
## Stage 7

The **rear edge of the folded wings reaches the front edge of the sharply defined white between the black rump and the tail**. This stage ends when the feathers of the folded wing reach the back edge of the white band at the rear of the body and in front of the tail.



## Stage 8

The **feathers of the folded wing extend over the white band to reach the end of the body near the tail**. The flight feathers continue to grow and extend over the tail.



## The Detailed Key (for AS/A2 and Advanced Higher students)

The students use the key to allocate the 32 pictures in the 'Preliminary' folder. Some of these are quite straightforward but a few require an assessment of all the details of the key, not just the diagnostic points (or information) in ***bold italic script***. A check sheet S3 (Advanced students) is provided for a sample of 20 images: two check sheets per student would be needed if they allocate all 32 images.

Immature Canada geese can fly at an age of about 70 days. At this time their plumage quite closely resembles that of adult birds. Prior to this their plumage goes through a series of eight more or less distinct stages which are approximately related to the age of the gosling. The characteristics of these eight stages are described below. Stages one and two are distinctly different but do not have clear cut boundaries. For stages three to eight diagnostic boundaries have been established and are shown in italics. [N.B. There is some overlap in the length of the periods.]

The quality of the final classification can be assessed in two ways. The first of these is to calculate a percentage agreement between the classification produced by the student and the 'correct' assignment to stages. [For the correct allocation see the explanation on page 17 'a note for teachers']. The second method is to calculate a test statistic called **Cohen's Kappa**.

## Calculating Cohen's Kappa

The problem with calculating a simple percentage agreement between the derived and 'correct' classification is that it does not take account of chance factors. A proportion of the agreements would have arisen by chance. Cohen's *Kappa* statistic takes this into account. A computer program is provided which will do the calculation for you. Alternatively it can be done by hand. Below is the formula for finding the value of the Kappa statistic:

$$Kappa = \frac{P_{obs} - P_{exp}}{1 - P_{exp}}$$

$P_{obs}$  is the proportion of agreement observed;

$P_{exp}$  is the proportion of agreement expected by chance.

These two values can be calculated as follows. In this worked example, five students were given 8 images to allocate to the correct stages.

Start by producing an 8 x 8 matrix or table, see Table 1. Label the rows and columns with the numbers 1 to 8. Assume that columns are the 'correct' stage and rows are the classification by the student. This table will be required even if students use the computer program. [A blank outline (Table 4) is provided for use by students for Tables 1,2 and 3.]

**Fig 3 Stages in plumage development in Canada goose goslings (AS/A2/Advanced Higher)**

## Stage 1

A very young gosling is small, round, downy and mostly yellow on the underside extending towards the head. Over time the yellow gradually fades and the back changes from yellow to a pale dusky brown (greyish) later. The legs and neck are short and the neck is not distinct. Age 1 to 9 days.



## Stage 2

Goslings are still downy and with some yellow still evident on the head and upper neck. The yellow on the body has now faded to a pale dusky brown. When a gosling is viewed from the side the wings can be seen but there is no evidence of feathers. The neck is distinct and the posture is more upright. Age 10 to 24 days.



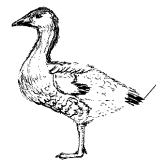
## Stage 3

When viewed from the side the **wing feathers are clearly visible**, but the rest of the body remains covered with a more or less uniform dusky brown down, somewhat lighter on the underside. The neck has further elongated to become 'serpentine' or 'snake-like'. This stage ends when the first tail feathers appear. Age 19 to 31 days.



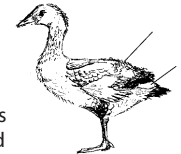
## Stage 4

This stage is reached when the **first black tail feathers become clearly visible** (about 5mm in length). During this stage feathers can be seen on the sides, wing and belly. From some angles the white cheek patch may be just visible but overall the colour of the back and neck is dusky brown. Towards the end of this stage black (or very dark brown) soft downy feathering appears at the rump and the rear underside is becoming paler. This stage ends when white feathers appear on the dorsal surface in front of the black tail and behind the dark feathering on the rump. Age 24 to 38 days.



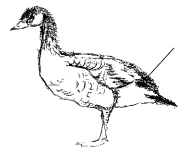
## Stage 5

This stage is reached when the **white patch between the black tail and dark brown or black rump becomes clearly visible**. The overall coloration of the back surface and neck is still dusky brown but clearly feathered. The area under the tail becomes paler and later in this stage this is white. The white cheek patch becomes more visible and the neck darkens. This stage ends when the rear underside is more or less white, the cheek patch is clearly visible and the neck is black along more or less all of its length. The black neck and head still carry significant amounts of down. Age 30 to 45 days.



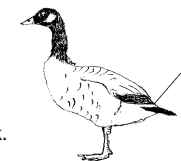
## Stage 6

This stage is reached when the **rear underside is white not pale buff, the white cheek patch is clearly visible, and the head and neck are black but still have considerable down**. The rear underside is white. Initially the rear edge of the folded wings does not reach the front edge of the black or dark brown patch on the rump which appears downy. By the time the head and neck have lost much of the remaining down the wing feathers have grown to reach the front edge of the black patch on the rump. This stage ends when the folded wings just reach the rear edge of the of the black (dark brown) rump. Age 45 to 60 days.



## Stage 7

This stage is reached when the **rear edge of the folded wings reaches the front edge of the sharply defined white area between the black rump and tail**. During this stage the feathers of the folded wing grow to reach beyond the front edge of this white band but do not reach the rear edge. The white cheek patch becomes more sharply defined. This stage ends when the feathers of the folded wing reach the back edge of this white band at the rear of the body and in front of the tail. Down is still visible on the sides of the neck. Age 59 to 69 days.



## Stage 8

This stage is reached when the **feathers of the folded wing extend over the white band to reach the end of the body near the tail**. During this stage further development of the feathers causes the folded wings to extend beyond the rear of the body and over the tail. The neck is well defined but may still carry traces of down. The breast is still distinctly marked and the cheek patches are well defined but may not yet be pure white. Stage 8 is usually entered at 66 to 68 days. It is close to, but not identical with, the adult plumage.





Stages allocated by students

Correct stages

Stage	1	2	3	4	5	6	7	8
1								
2								
3								
4								
5								
6								
7								
8								

**Table 2 Example of a completed matrix - frequencies**

In each cell of the table make a tally of the correct and incorrect assignments to stages.

Stage	1	2	3	4	5	6	7	8
1								
2								
3								
4								
5								
6								
7								
8								

The resulting matrix is called a 'confusion matrix'. It is interpreted as follows (for cell 1,1), 'four of the images of stage 1 goslings were correctly assigned but a fifth was incorrectly assigned to stage 2'. Now convert the 'tally count' to numbers.

Table 3 Example of a completed matrix - totals

Stage	1	2	3	4	5	6	7	8
1	4	1						
2		5						
3			5					
4				3	2			
5				2	3			
6						5		1
7							4	
8							1	4

We can calculate the observed proportion,  $P_{obs}$ , by adding together all the scores in the cells of the main diagonal which runs from top left to bottom right of the table and dividing by the total number of scores in the cells which corresponds to the number of images.

$$P_{obs} = \frac{4 + 5 + 5 + 3 + 3 + 5 + 4 + 4}{40} = 0.825$$

[If  $P_{obs}$  is multiplied by 100 it gives the percentage of images correctly assigned.  
**0.825 x 100 = 82.5%** of the images were correctly assigned.]

To calculate  $P_{exp}$  start by finding the row totals and the column totals. For row 1 this is **4 + 1 = 5** and for column 1 this is **4**. Do this for the remaining rows and columns.

$P_{exp}$  is calculated by adding together the row total multiplied by the column total for all the rows and columns, and dividing by the square of the number of items classified.

$$P_{exp} = \frac{5 \times 4 + 6 \times 5 + 5 \times 5 + 5 \times 5 + 5 \times 5 + 6 \times 5 + 4 \times 5 + 5 \times 5}{40 \times 40}$$

$$P_{exp} = \frac{20 + 30 + 25 + 25 + 25 + 30 + 20 + 25}{1600}$$

$$P_{exp} = 0.125$$

These values can now be substituted into the formula for *Kappa*.

$$Kappa = \frac{P_{obs} - P_{exp}}{1 - P_{exp}}$$

$$Kappa = \frac{0.825 - 0.125}{1 - 0.125}$$

$$Kappa = 0.8$$

One commonly accepted convention is to regard a kappa value of 0.40 to 0.60 as fair, 0.61 to 0.75 as good, and over 0.75 as excellent.

## Extension work

Cohen's *Kappa* can also be used as a measure of inter-observer agreement. Pairs of students could assign the same group of gosling images to stages, construct a confusion matrix and calculate *Kappa*.

Students could discuss whether all incorrect assignments are equally serious. For example, is the error of assigning a stage 6 gosling to stage 7 as serious as assigning a stage 6 gosling to stage 3?

Can the ability to allocate images of goslings to the correct stage be improved by training? For example, students could initially assign the 'Preliminary' images to stages and then be shown the images in the 'Training' folder. When they are asked to assign the 'Extension' images to stages does their score improve? (N.B. Development is a continuous process and the 'Training' images have been chosen to reflect this.)

## The pre-nesting behaviours of sandwich terns (AS/A2/Advanced Higher)



*Adult sandwich tern returning to the nesting colony with a fish in its bill*

## *Behavioural descriptions*

Below are descriptions of behavioural units, or elements, which have been observed being performed by sandwich terns, *Sterna sandvicensis*, during the pre-nesting period. Two of the behaviours described are composed of a combination of the simpler units.

- 1. Advertisement calling.** The body axis points slightly upwards at an angle of up to 30° to the horizontal. The neck is withdrawn (not stretched), and the carpal joints (the equivalent of the wrist joints, and clearly evident in drawings a – d), the crest and the body feathers are conspicuously raised. Head and bill point in the direction of a tern flying overhead carrying a fish. The bird calls loudly and maintains its position with respect to the fish carrying conspecific by turning around. [A conspecific is another animal of the same species, in this case another sandwich tern.]
- 2. Begging.** The bird rhythmically calls in a hunched position. The body axis is horizontal, head and neck are withdrawn between the shoulders. At every call the head and bill move up and down between 0° and 30° with respect to the horizontal.
- 3. Circling.** Two birds walk around each other in the stretch posture, see `Stretch posture` behaviour (10) for a description of this. The body axes are roughly parallel to each other and the birds are in a head to tail position with respect to one another. The carpal joints are conspicuously raised and sometimes hook each other. As a consequence both birds may appear to walk 'arm in arm'. The whole procedure may last from a few seconds to several minutes.
- 4. Copulation.** The body of the female is between the horizontal and sloping slightly downwards. The neck is withdrawn (not stretched); head and neck point upwards at an angle of between 30° and 80° with the horizontal. During copulation the female may peck the breast of the male. The body axis of the male makes an angle of roughly 45° with the horizontal. The legs are bent and the wings are spread. The neck is stretched in an upward direction; head and bill point downwards. During cloacal contact the male beats his wings.
- 5. Erect posture.** The carpal joints are raised and the neck is vertically stretched as in the 'high intensity' stretch posture. However, the head is almost aligned with the neck and the body axis points more upwards (up to 60° with the horizontal).
- 6. Fighting.** In the threat position both opponents seize each other's bill and bite, twist and pull. When fighting in a standing position the wings are often raised but are never used to beat the opponent.
- 7. Fixating.** The body axis is horizontal. The neck is held in line with the body axis, and the head and bill point vertically downwards. The birds stand motionless apparently fixating the ground.
- 8. Scraping.** The bird lies with its breast on the ground. Sand is thrown away from beneath the body by means of a backward scraping movement of the legs.
- 9. Stooping.** The body axis points downwards up to 40° with the horizontal. The neck is held at an angle of roughly 90° with the body axis. The head is turned downwards and the bill usually points to the ground. The carpal joints are usually raised.
- 10. Stretch posture.** The neck is vertically stretched and the carpal joints are raised. During the 'high intensity stretch' the body axis points upwards at an angle of 45° to the horizontal and the tail may be raised at the same angle to the horizontal. In general the head is held horizontally, but in certain situations the head and bill may be bent downwards. This is seen when a bird offers a fish to a conspecific whilst performing the stretch posture.
- 11. Threat posture.** Head and neck are stretched in the direction of another bird. The carpal joints, crest, neck and body feathers are raised. In 'high intensity threatening' the head and neck rhythmically move up and down. Threatening may occur in a sitting as well as a standing position.

In the field the different behavioural units can be identified in the terns by observing the orientation with respect to the horizontal of the main axis of the body, the head, bill, neck and wings, see Figure 4. [A larger version of the drawing is available for students, see Figure 4A.] For example, in Figure 4(e) the main axis is shown as a line inclined downwards. Other distinguishing factors are descriptions of the elongation or movement of body parts, the raising of body and/or crest feathers, and the orientation or movement of an individual with respect to another tern, i.e. a conspecific.

The task for the students is to look carefully at the drawings (a to k), see Figure 4A, and match the correct drawing with the written description (1 to 11) of the behaviour. A table (S4) is provided for them to record their answer, and this also explains what they need to do.

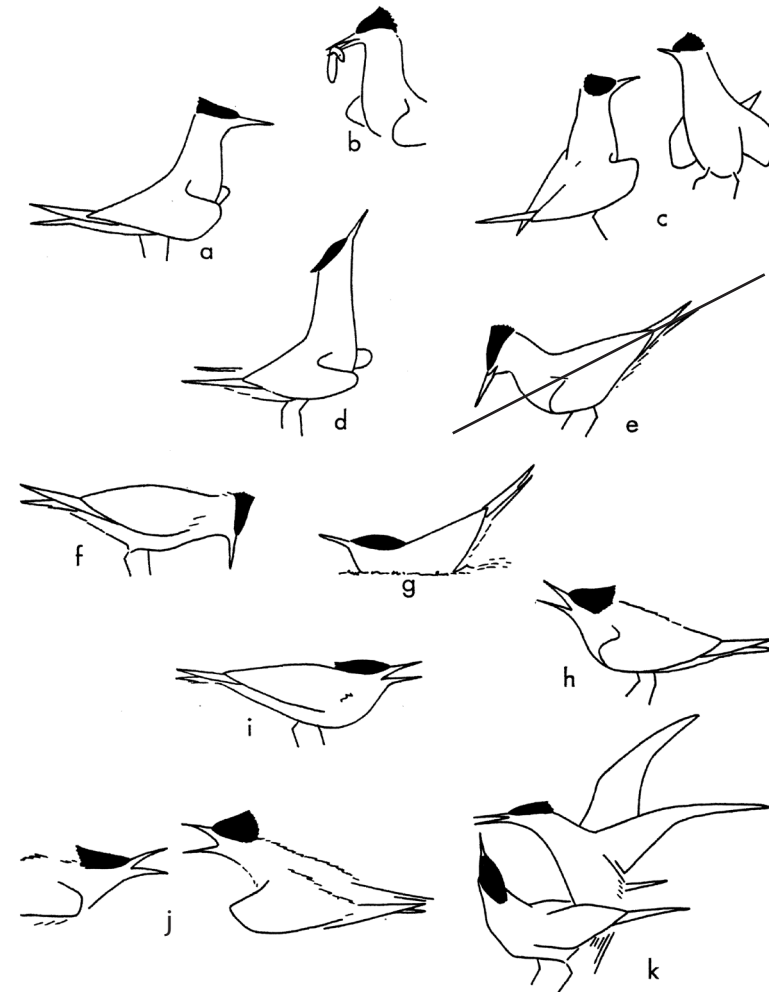
The correct matching of the description and drawings is listed at the end of this resource, see page 17.

## Task for students

You are required to look carefully at the drawings (a to k), see Figure 4A, and match the correct drawing with the written description (1 to 11) of the behaviour. A table (S4) is provided for you to record your answer. Simply fill in the letters a to k so they match with the descriptions 1 to 11.

Look very carefully at each drawing, and especially at the head, bill (beak), neck, wings and the main axis of the body. [The axis is shown in drawing e, here the main axis of the body is shown at an angle to the ground.] Other important factors are descriptions of the movement of the body parts, the raising of the body and/or the crest feathers and the movement of an individual bird with respect to another sandwich tern. Do not assume that in every case there is a one-to-one correspondence between the descriptions and the illustrations.

Figure 4. Behaviours shown by sandwich terns in the pre-nesting period



## Writing descriptions of the behaviours and postures of Canada geese (for AS/A2 and Advanced Higher students)

### *Background for teachers*

The directory 'Behaviours' contains images of Canada Geese performing seven different behaviours or postures. These are 'Extreme Head Up' (10 images), 'Feeding' (6 images), 'Head on Back' (4 images), 'Head Low' (7 images), 'Head Up' (4 images), 'Sitting' (4 images), 'Standing' (3 images) and 'Sitting and Sitting' (1 image). [N.B. One image shows two geese, one of which is standing and one of which is sitting.] These have been selected to show the range of expression of these different postures or behaviours which might be observed in the field.

Students could be asked to write *unambiguous* descriptions of these behaviours. A good description will encompass the full range of expression of the behaviours shown in the images and it will enable a reader to differentiate each behaviour from any other. A table is provided for their answers, see Table 5.

This is most easily accomplished if a description relies upon the relative orientation, and extension of body parts, the alignment of body axes and (where appropriate) direction of movement.

N. B. This is a much more challenging exercise than it appears at first sight. So teachers may suggest that students work together in small groups, as this should make the task more amenable. Students should not assume that a reader has *any* pre-existing knowledge of the behaviour of a Canada goose.

Below are *minimal* descriptions of the behaviours.

**Extreme Head Up:** The neck stretched so that the back of the neck is all above the level of the back. When standing the body axis is usually more or less towards the vertical.

**Feeding:** The bill is below the level of the base of the neck and pointing downwards. The bird is either pecking or uprooting food, or scanning the ground between bouts of pecking.

**Head on Back:** The bird has its bill resting on, or under, the wing. The eyes may, or may not, be closed.

**Head Low:** The bird has its bill level with, or a little above, the level of the back. The neck is sometimes bent and the head is held over the back or just above the base of the neck. If the neck is straight the neck feathers are raised a little and the neck appears 'chunky'.

**Head Up:** The bill is above the level of the back but the neck is not stretched and some of the back of the neck is at, or below, the level of the back.

**Sitting:** At least one leg is more or less parallel with the ground. The weight of the bird is not supported by the legs. (*Geese often sit with one leg extended from the body.*)

**Standing:** At least one leg is more or less at right angles to the ground and apparently supporting the weight of the bird. (*Geese often stand on one leg.*)

Some of these behaviours are not mutually exclusive. For example, geese can adopt the 'Head Low' posture when swimming, standing or sitting. You may prefer to consider the latter as 'modifiers'.



The pictures of the Canada Goose goslings each carry a numeric code in one corner. From this you can immediately work out the 'Stage' of the gosling in the picture. Just find the sum of the digits and note the rightmost digit of the result. This gives the 'stage' of the gosling. For example  $0777 = 0 + 7 + 7 + 7 = 21$ . The rightmost digit is a '1' so the gosling must be Stage 1.

Labels for the the pre-nesting behaviours of Sandwich Terns are matched to the diagrams as follows.

Stretch posture = a and b

Circling = c

Erect posture = d

Stooping = e

Fixating = f

Scraping = g

Advertisement calling = h

Begging = i

Fighting = j : both birds are showing the threat posture

Copulation = k

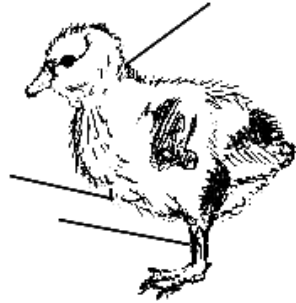
## Acknowledgements

ASAB is very grateful to Dr Jan Veen for giving permission to use his drawings showing the pre-nesting behaviours of sandwich terns. The photographs were mainly provided by the author and the illustrations of the goslings by Ann M. Williams. ASAB would also like to thank Mick Hoults for designing the resource pack and providing the cover photograph. The image of the sandwich tern comes from the website of the US Fish and Wildlife Service. Finally, ASAB is particularly grateful to the Headmistress, Dr Cristina Vilela and Year 11 students at Withington Girls' School for allowing Michael Dockery, (the ASAB Education Officer), to trial the resource at the school.

# Sheet S1 (GCSE)

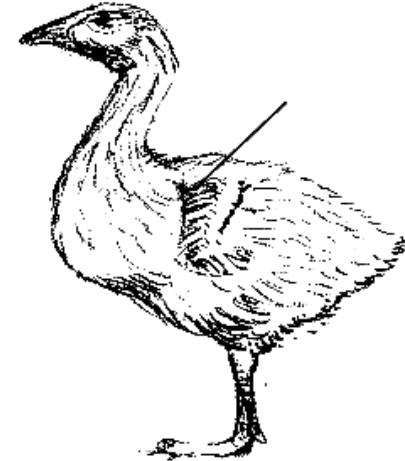
## Stage 1

A very young gosling is small, round, downy and mostly yellow on the underside extending towards the head. The legs and neck are short and the neck is not distinct. Over time the yellow gradually fades and the back changes from yellow to a pale dusky (greyish) brown.



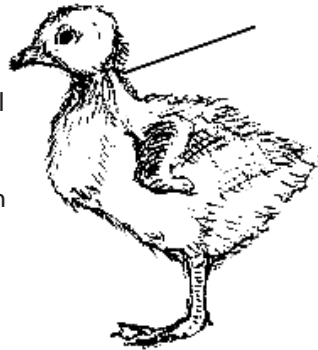
## Stage 3

When viewed from the side **wing feathers are clearly visible**. The rest of the body remains covered with a more or less uniform dusky brown down. The neck appears longer and 'serpentine' or 'snake-like'. This stage ends when the first tail feathers appear.



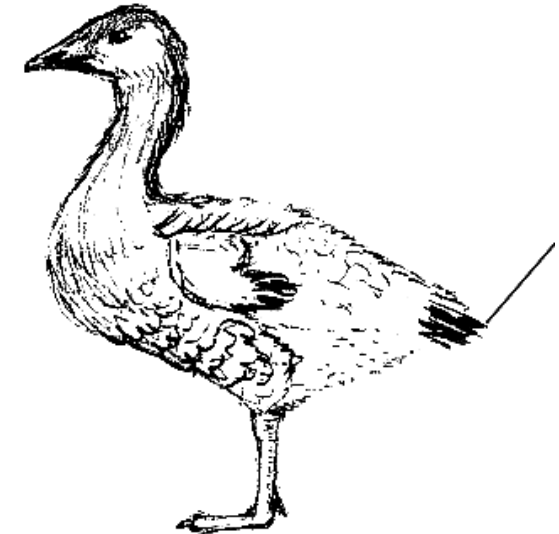
## Stage 2

A gosling is still downy and with some yellow still evident on the head and upper neck. The yellow on the body has now faded to a pale dusky brown. When viewed from the side the wings can be seen but there is no sign of feathers. The neck is distinct and the posture is more upright.



## Stage 4

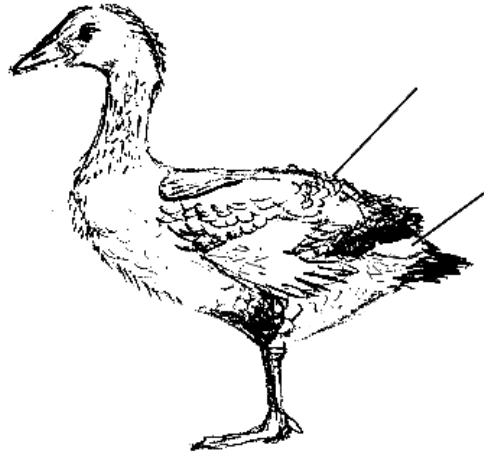
This stage is reached when the **first black tail feathers become clearly visible** (about 5mm in length). The colour of the back and neck is dusky brown. Feathering can be seen on the sides, wings and belly. Later black (or very dark brown) soft downy feathering appears at the rump. This stage ends when white feathers appear on the upper surface in front of the black tail and behind the dark feathering on the rump.



# Sheet S2 (GCSE)

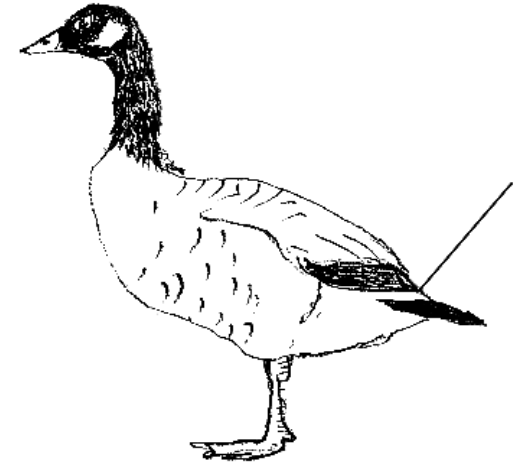
## Stage 5

The **white patch between the black tail and dark brown or black rump becomes clearly visible**. During this stage feathers can be seen on the sides, wings and belly. The overall coloration of the back and neck is still dusky brown. During stage 5 the white cheek patch becomes more visible and the neck darkens. The stage ends when the cheek patch is clearly visible and the neck is black along more or less all of its length.



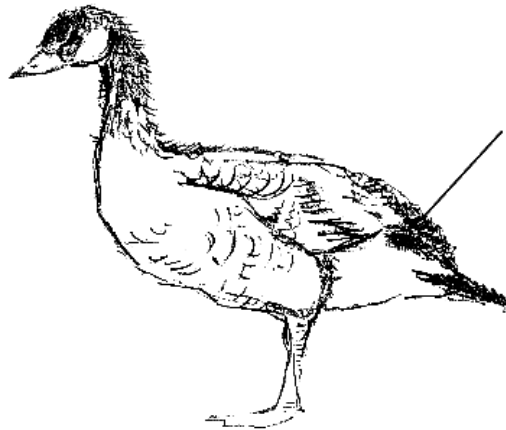
## Stage 7

The **rear edge of the folded wings reaches the front edge of the sharply defined white between the black rump and the tail**. This stage ends when the feathers of the folded wing reach the back edge of the white band at the rear of the body and in front of the tail.



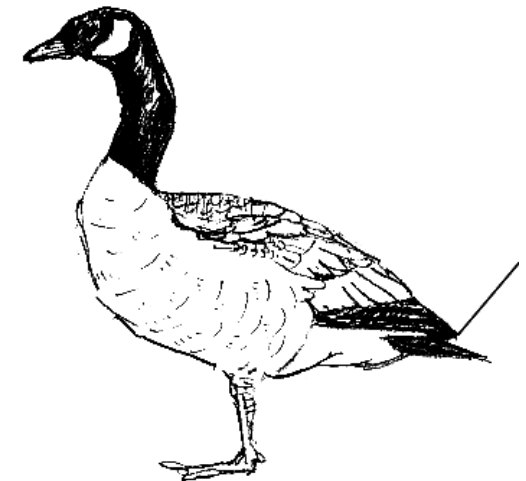
## Stage 6

This stage is reached when **the white cheek patch is clearly visible, and the head and neck are black but still carrying considerable down**. This stage ends when the folded wings have grown to just reach the back edge of the black (dark brown) rump.



## Stage 8

The **feathers of the folded wing extend over the white band to reach the end of the body near the tail**. The flight feathers continue to grow and extend over the tail.



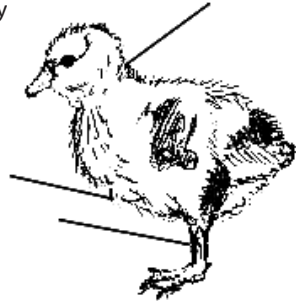
## S3 Check Sheet — GCSE students

Image code	Allocated stage	True stage	Difference	Square of difference
0022				
0070				
0170				
0231				
0364				
0858				
0732				
0771				

# Sheet S1 (Advanced)

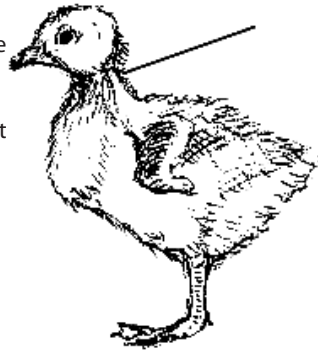
## Stage 1

A very young gosling is small, round, downy and mostly yellow on the underside extending towards the head. Over time the yellow gradually fades and the back changes from yellow to a pale dusky brown (greyish) later. The legs and neck are short and the neck is not distinct. Age 1 to 9 days.



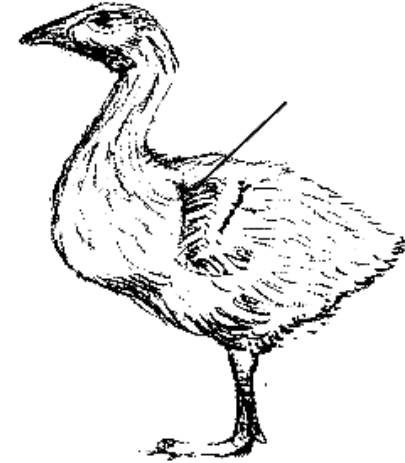
## Stage 2

Goslings are still downy and with some yellow still evident on the head and upper neck. The yellow on the body has now faded to a pale dusky brown. When a gosling is viewed from the side the wings can be seen but there is no evidence of feathers. The neck is distinct and the posture is more upright. Age 10 to 24 days.



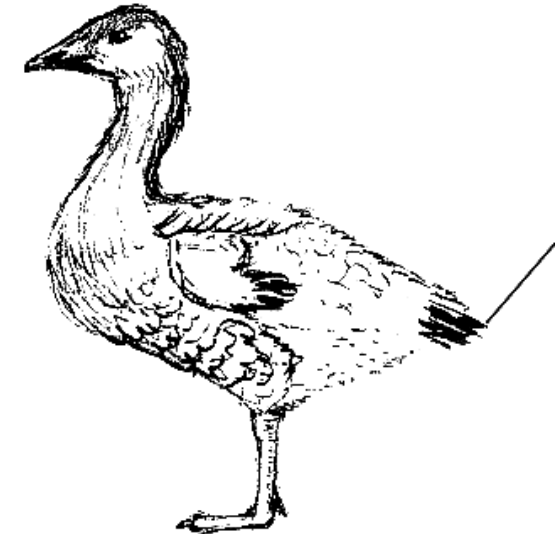
## Stage 3

When viewed from the side the **wing feathers are clearly visible**, but the rest of the body remains covered with a more or less uniform dusky brown down, somewhat lighter on the underside. The neck has further elongated to become 'serpentine' or 'snake-like'. This stage ends when the first tail feathers appear. Age 19 to 31 days.



## Stage 4

This stage is reached when the **first black tail feathers become clearly visible** (about 5mm in length). During this stage feathers can be seen on the sides, wings and belly. From some angles the white cheek patch may be just visible but overall the colour of the back and neck is dusky brown. Towards the end of this stage black (or very dark brown) soft downy feathering appears at the rump and the rear underside is becoming paler. This stage ends when white feathers appear on the dorsal surface in front of the black tail and behind the dark feathering on the rump. Age 24 to 38 days.

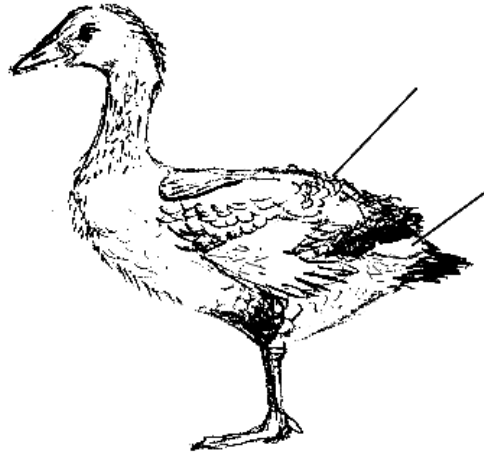


# Sheet S2 (Advanced)

## Stage 5

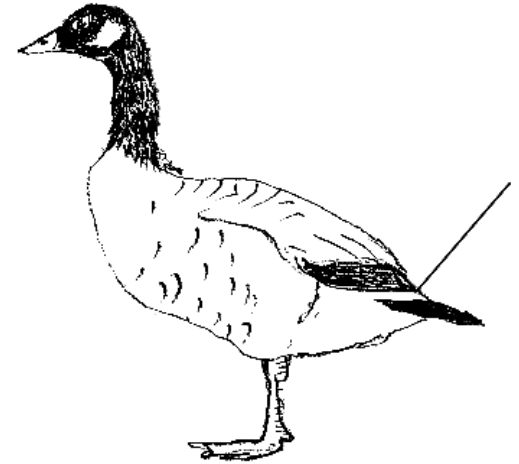
This stage is reached when the **white patch between the black tail and dark brown or black rump becomes clearly visible.**

The overall coloration of the back surface and neck is still dusky brown but clearly feathered. The area under the tail becomes paler and later in this stage this is white. The white cheek patch becomes more visible and the neck darkens. This stage ends when the rear underside is more or less white, the cheek patch is clearly visible and the neck is black along more or less all of its length. The black neck and head still carry significant amounts of down. Age 30 to 45 days.



## Stage 7

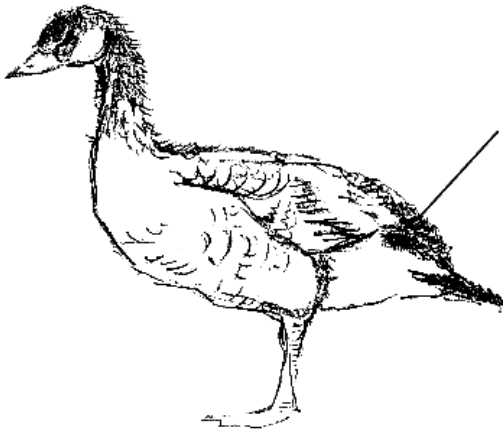
This stage is reached when the **rear edge of the folded wings reaches the front edge of the sharply defined white area between the black rump and tail.** During this stage the feathers of the folded wing grow to reach beyond the front edge of this white band but do not reach the rear edge. The white cheek patch becomes more sharply defined. This stage ends when the feathers of the folded wing reach the back edge of this white band at the rear of the body and in front of the tail. Down is still visible on the sides of the neck. Age 59 to 69 days.



## Stage 6

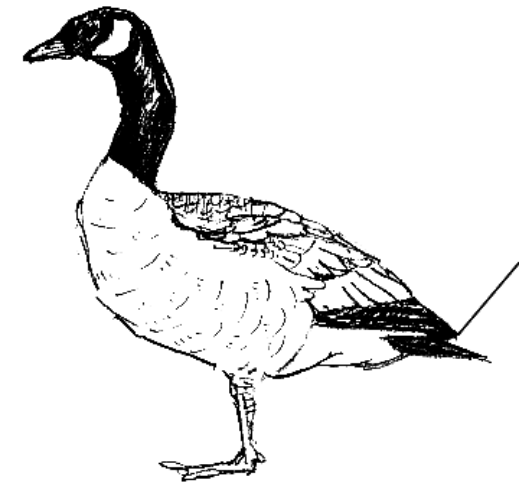
This stage is reached when the **rear underside is white not pale buff, the white cheek patch is clearly visible, and the head and neck are black but still have considerable down.**

The rear underside is white. Initially the rear edge of the folded wings does not reach the front edge of the black or dark brown patch on the rump which appears downy. By the time the head and neck have lost much of the remaining down the wing feathers have grown to reach the front edge of the black patch on the rump. This stage ends when the folded wings just reach the rear edge of the of the black (dark brown) rump. Age 45 to 60 days.



## Stage 8

This stage is reached when the **feathers of the folded wing extend over the white band to reach the end of the body near the tail.** During this stage further development of the feathers causes the folded wings to extend beyond the rear of the body and over the tail. The neck is well defined but may still carry traces of down. The breast is still distinctly marked and the cheek patches are well defined but may not yet be pure white. Stage 8 is usually entered at 66 to 68 days. It is close to, but not identical with, the adult plumage.



# S3 Check Sheet — AS/A2/Advanced Higher students

(For the 'Preliminary' and the 'Extension' exercises)

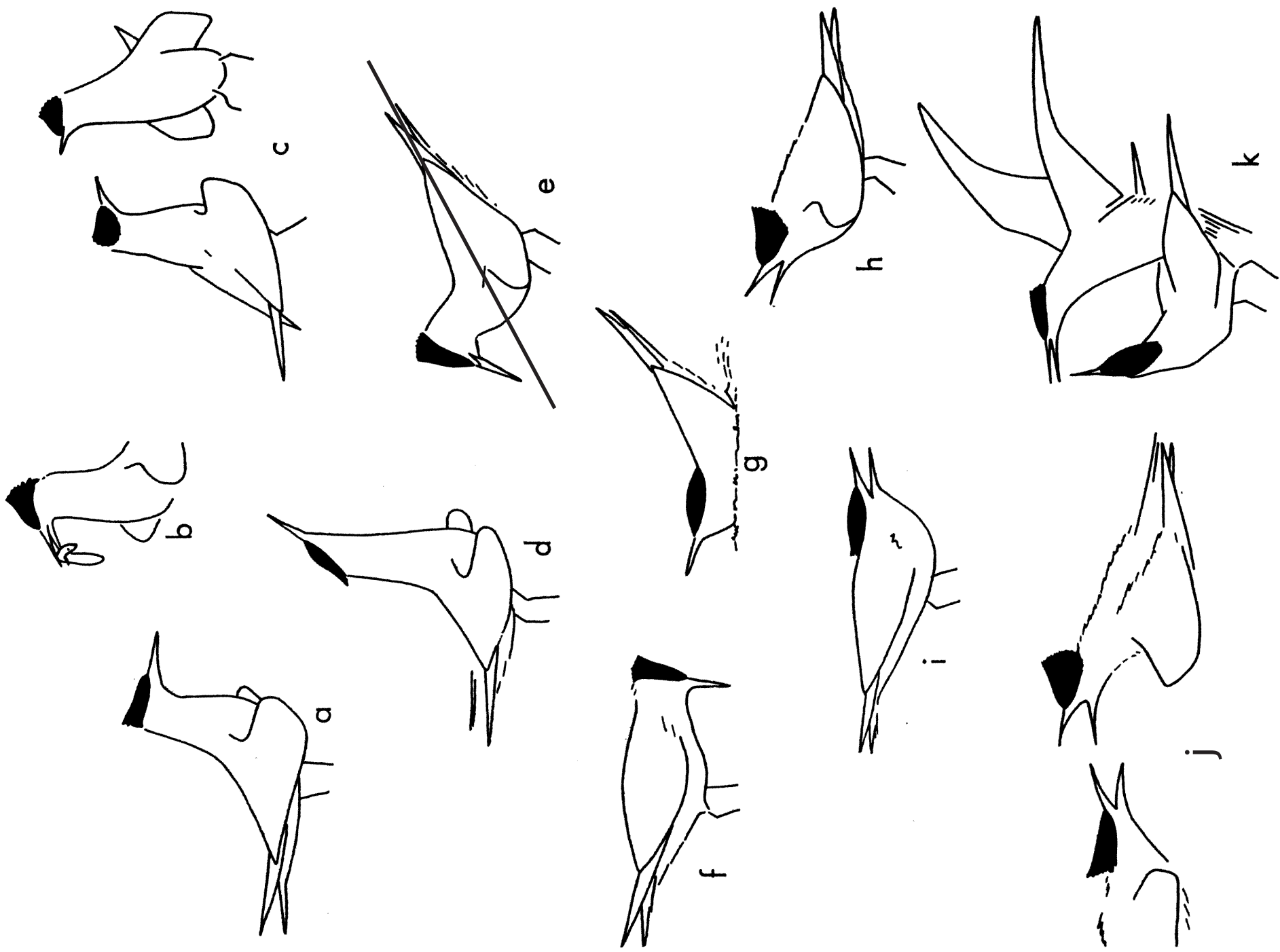
True stage																			
Allocated stage																			
Image code																			

Table 4 Blank outline for use with AS/A2/Advanced Higher students

<b>Stage</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
<b>1</b>								
<b>2</b>								
<b>3</b>								
<b>4</b>								
<b>5</b>								
<b>6</b>								
<b>7</b>								
<b>8</b>								



Figure 4A Behaviours shown by Sandwich terns in the pre-nesting period



## The pre-nesting behaviours of sandwich terns

**Table S4**

<b>Description of behaviour</b>	<b>Drawing</b>
1. Advertisement calling	
2. Begging	
3. Circling	
4. Copulation	
5. Erect posture	
6. Fighting	
7. Fixating	
8. Scraping	
9. Stooping	
10. Stretch posture	
11. Threat posture	

### Task for students

You are required to look carefully at the drawings (a to k) and match the correct drawing with the written description (1 to 11) of the behaviour. A table (S4) is provided for you to record your answer. Simply fill in the letters a to k so they match with the descriptions 1 to 11.

Look very carefully at each drawing, and especially at the head, bill (beak), neck, wings and the main axis of the body. [The axis is shown in drawing e, here the main axis of the body is shown at an angle to the ground.] Other important factors are descriptions of the movement of the body parts, the raising of the body and/or the crest feathers and the movement of an individual bird with respect to another sandwich tern. Do not assume that in every case there is a one-to-one correspondence between the descriptions and the illustrations.

Table 5 Description of Canada goose behaviour or posture

<b>Behaviour/Posture</b>	<b>Description</b>
<b>Extreme Head Up</b>	
<b>Feeding</b>	
<b>Head on Back</b>	
<b>Head Low</b>	
<b>Head Up</b>	
<b>Sitting</b>	
<b>Standing</b>	