# 7 Reproduction

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Reproduction is a crucial phase in the life cycle of any organism. It is the way in which individuals leave descendants and a species is perpetuated, given that individuals must eventually die. Most students will know that all living organisms grow and reproduce. However, they may have only limited understanding of reproductive processes, including limited understanding of asexual reproduction.

Students' previous experiences of practical work with plant materials, such as flower structures, can be developed and gaps in knowledge addressed. Extending students' knowledge of different types of seed dispersal (to include wind, water and animal dispersal) is also helpful. Students frequently confuse seed dispersal with types of pollination, and they may also confuse pollination with fertilisation. Clarification can be followed up with more detailed work on the reproduction of a specific animal, such as a frog or fish.

Care will be needed in planning for practical work with respect to the seasons and availability of specimens. Observation of the cycles of reproduction in plants generally requires long-term planning, though SAPS (Science and Plants for Schools) resources using rapid-cycling brassicas can make this more easily achievable. Find out if students have had the opportunity to grow or propagate plants or examine in detail a variety of living organisms. Providing students with this opportunity need not be expensive nor require a lot of space. It will be rewarding and inspiring if every student can plant a seed or take, and subsequently root, a cutting. Students should know the structure of a typical seed and appreciate how this relates to germination and the stages in a plant's life cycle.

The topic of reproduction provides abundant opportunities for bringing living things into your laboratory or classroom and providing students with hands-on experience. Whilst many schools may not have a well-stocked school greenhouse or pond, windowsills or communal areas can provide access to a variety of seasonal plant species. The value of this cannot be over-estimated since this is a key opportunity to provide students with skills and understanding for life, as well as fulfil aspects of the science curriculum. It can also engender in students a sense of success and manifest the 'awe and wonder' of how a single, small seed

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can give rise to something as impressive as an oak tree or the food we eat. Linking ideas of basic science to the wider issues of food security and the global environmental is desirable.

Animal sexual reproduction presents good opportunities for maintaining and observing a variety of organisms throughout their life cycle. Some species need little laboratory space and may have a life cycle that can be watched over just two weeks and independently of the seasons (e.g. fruit fly). Others may demand more extensive maintenance, space and equipment, requiring observation over many weeks or months, and within specific breeding seasons.

The whole topic of reproduction links directly with 'growth and development' in plants and in animals. Basic microscopy skills are assumed in this chapter, and students' ideas to do with size and the concept of magnification can be reinforced and extended. It is useful for students to know how to estimate the size of the cells they are examining (see Chapter 2). It is important to include examples of plant cells and to reinforce the similarities and differences between plant and animal cells.

Finally, your students need a firm understanding of the basics of nuclear and cell divisions, which lead to the formation of *either* genetically identical cells (as a result of mitosis) *or* gametes (as a result of meiosis) (see Chapter 2). They also need a grasp of the role of DNA in the control of the cell's activities by the nucleus (see Chapters 2 and 8). Plant examples, such as growing cloves of garlic in the top of a test tube of water and using these for observing mitotic division of cells, can provide simple and effective practical activities.

Teaching about human reproduction and other aspects of sex education can present challenges to any teacher. Schools vary in their delivery of this area, in some cases deploying a well-integrated, whole-school approach; in other cases devolving much of the area of study to the science department. It is crucial, as a teacher of biology, that you are well informed about your school's policy for sex education, and about the precise part that you, as a science teacher, are to play in this sensitive area of education. Science teachers not only need to provide accurate information about reproduction and sexual health, but also to have strategies ready to deal with questions, some of which may be awkward, that might arise.

## 7.1 Asexual reproduction in plants and animals

## Previous knowledge and experience

Students are likely to have met aspects of reproduction in plants and animals but that will mostly have been concerned with sexual rather than asexual reproduction.

## Advantages of asexual reproduction

Using a variety of examples, teachers can show students that asexual reproduction has several advantages over sexual reproduction:

- no energy is wasted in finding a mate
- many offspring are produced rapidly
- favourable circumstances can be exploited very efficiently
- desirable traits are ensured in offspring.

## Examples of asexual reproduction

A variety of organisms can be used to show that there is only one parent in asexual reproduction. In each case some part of this parent divides to produce an identical individual, which then separates from the parent. A circus of activities (suggestions are largely seasonal) can provide an overview of the range of mechanisms for asexual reproduction in plants and animals:

- Estimation of the number of plantlets associated with a spider plant or *Bryophyllum*: ask students to suggest reasons for the production of so many. Refer to the common name of *Bryophyllum* (mother of thousands) and ask students why this might be relevant.
- Illustration of reproduction (fission) in a bacterium or a unicellular organism, such as *Amoeba proteus*: use a sequence from a video.
- Bread-mould cultures: observe the development of colonies of mould (a fungus) and the tiny black dots (sporangia) containing the spores. Ask students to suggest how these may be dispersed. Some fungal spores can trigger asthmatic and other allergic responses, so do keep cultures in closed plastic bags. The use of a visualiser would be helpful here. This

can limit potential hazards associated with allergic responses, whilst allowing for whole class participation and engagement.

## Mitosis

Build on your students' basic knowledge of mitosis. Explore with them the role of this division: it allows cells (and therefore whole organisms) to reproduce themselves to form genetically identical offspring ('daughter cells'). You can extend this to make links with the role of mitosis in allowing multicellular organisms to grow and to repair themselves. Mitosis should eventually be understood as the basis of asexual reproduction (see Chapter 2). Refer students to practical work on plants; this helps to link theory securely to context.

## Cloning and tissue culture

Asexual reproduction results in genetically identical individuals and means that a clone (e.g. a clump of daffodils) results from a single organism. You can consider examples from horticulture and agriculture (e.g. strawberries and pineapples) where the advantage is that particular genetically-based characteristics of the crop plant can be maintained from one generation to the next. Consider also how a change in an aspect of the environment, e.g. prolonged drought, can be a disadvantage to a species that is reliant on asexual reproduction. Notice how a range of wild plants (e.g. grasses) use both methods of reproduction, so that the disadvantages of cloning become less significant (see Chapter 9). Emphasise the fact that the term 'clone' applies to individuals produced naturally by asexual reproduction as well as those produced by artificial cloning. This is something students often do not appreciate.

Tissue culture is a way of conducting asexual reproduction on a massive scale; the process is now a routine laboratory and commercial procedure, and examples can help students to appreciate the extent to which this is part of everyday life. This is an ideal opportunity to encourage students to discuss cloning in a balanced way in order to highlight and clarify some of the advantages to society of these techniques. Cloning animals is not as easy as cloning plants. The activity of cloning cauliflowers can be used here to show the advantages of cloning in context. If this is not available to do as a demonstration or class practical, use the SAPS video clip showing the technique (www.saps.org.uk *Cauliflower Cloning – Tissue*

*Culture and Micropropagation*.) There are teaching notes, student worksheets and illustrated worksheets.

## Cancer

Few young people have a good understanding of what constitutes cancerous growth. You can provide help by making the link with asexual reproduction in terms of uncontrolled cell division (mitosis). A video sequence can demonstrate the irregular mass of cells (a tumour) that may have come about as a result of mutation in the genes that control cell division (see Chapter 8). Students need to understand that plants also show periods of unchecked cell divisions with the development of a tumour. Understanding this should help to reinforce the fact that plants have many of the same processes as animals.

Useful secondary data can raise older students' awareness of the ways in which scientists begin to correlate the incidence of a disease with a particular factor. This is also an opportunity to talk about different carcinogens (ionising radiation, certain chemicals) and some viruses, all of which are linked with the promotion of cancerous growths in both plants and animals.

Treat the topic with some sensitivity since a student may have / have had a relative or friend who has suffered from, or is being treated for, cancer. It is unlikely that everyone in a class will have been unaffected, and shared experiences can also be an opportunity to support or highlight students who need additional support – but never pressurise students to speak of their personal experiences.

## Further activities

Spring: to explore asexual reproduction in a practical context, record numbers of duckweed in a particular area of a pond over several days to demonstrate the rate of increase. This can be done on a micro-scale in the laboratory, using an old ice cream container and samples of duckweed.

Try some common horticultural methods:

- Late spring – stem cuttings (geranium, *Coleus*); leaf cuttings such as *Begonia rex*; layering ('pinks'), or African violets.

- Early summer – rooting the ‘buds’ of runners (strawberry), or rooting plantlets from spider plants (*Chlorophytum comosum*) or mother of thousands (*Bryophyllum daigremontianu*).

More advanced students could research tissue culture procedures, finding out how a callus is formed and how tiny plants are grown from subdivisions of this. Introduce this activity with a video sequence together with literature from commercial plant breeders (e.g. producers of hybrid orchids). The video clip from the TV Series *Botany: A Blooming History* (SAPS secondary teaching resources – genetic engineering to increase productivity in rice) could be used as it discusses the importance of genetic engineering for feeding a growing population. This links plant reproduction with the increasingly important issue of global food security. Further cultural context can be gained from considering how supermarkets can provide herb plants all year round.

**Enhancement ideas**

Examine yeast cells for signs of budding. Under the microscope, students can watch cells reach a certain size and produce outgrowths (buds), which eventually split to form new individuals. The use of an eyepiece graticule on the eyepiece lens of the microscope allows students to judge the size of the cells. A digital microscope linked to a data projector/screen or a visualiser provides for whole class observation of yeast division and structured discussion. A deflated balloon can be attached to the reacting vessel, and students are always entertained by its inflation by the gas produced, usually within an hour lesson. Time lapse photography could also be used to show the production of gas over time. A mathematical link could then be to provide students with data on volume of gas production over time, or students could plot data they have collected. Get students to think how the rate of production of gas is related to the number of yeast cells.

**Working scientifically**

Extend the work for investigative activities in which advanced students might explore the effects of culture temperature, or the amount of sugar, on the rate of cell division in yeast. Withdraw a drop of culture from the starter flask every 15 minutes and count the number of cells in the field of view. Plot a line graph to illustrate the increase in numbers of cells over

time or pool class data entered on a spreadsheet and obtain mean values and plots of rates of the increases in numbers.

Using Figure 7.1, ask students to explain what might be happening at X, Y, and Z. Explore possible reasons for why yeast eventually stops budding.

**[Insert Image – Figure 6.1 from 2nd edn]**

**Figure 7.1** The growth curve for yeast

## 7.2 Characteristics of sexual reproduction in plants and animals

### Previous knowledge and experience

Students will have met the idea of life cycles and will know the main stages of the human life cycle: humans produce babies who grow into children and then into adults. Similarly, they will have been introduced to the main stages of the flowering plant life cycle including growth, pollination, seed dispersal and the germination of seeds to form new plants. However, students are frequently unable to relate the life cycles of humans and plants. Often, students are unaware of the structure of a seed and are unclear as to how and why seeds germinate. Similarly, students can often label parts of a plant and describe the role of pollinators in pollination but are not clear about the mechanism of fertilisation in plants, and how this leads to production of seeds. Students may have a broad grasp of the fact that seeds disperse, but not the detail of mechanisms. Introduce students to the intriguing and sometimes bizarre ways that plants ensure their seeds are placed in the most advantageous position for subsequent germination.

### A teaching sequence

The sequence should try to explore the question, 'Why sexual reproduction, given the various advantages to asexual reproduction?'. The fundamental reason is that sexual reproduction gives rise to genetically-based variation amongst the offspring of the individual that is

reproducing. This makes it more likely, especially in a changing environment, that at least some offspring will survive and, in turn, reproduce themselves.

By considering and comparing different reproductive patterns in a range of animal species, students can be helped to forge links with the human reproductive pattern (Section 7.3).

**Examples of plant sexual reproduction**

Use every opportunity you have to check students' understanding of plant reproduction and different plant life cycles, building on teaching sequences from earlier stages. The idea that many plants can reproduce both asexually and sexually should be reinforced, using examples from across the plant kingdom as well as flowering plants, including grasses. This is a good opportunity to reinforce the role of grasses as food crops and link to food security and global climate changes.

Many flowering plants have interesting mechanisms for the production of specialised gametes; the male gametes are the pollen cells, found in the anthers; the female gametes are the ovules, found in the ovary. Meiosis is the special cell division that produces these gametes (see Chapter 2). Students could observe pollen under the light microscope and deduce whether the pollen is from a wind- or an insect-pollinated species. Students can be introduced to the idea that many (but not all) flowering plants are hermaphrodite, with the capacity to produce both male and female gametes. Try also to present examples of single-sex plants, such as the holly (*Ilex*) with its separate male and female plants. Students could compare these with other species of plants (e.g. birch, *Betula*) which are hermaphrodite. Students could then be asked to suggest mechanisms which prevent self-fertilisation in hermaphrodite species and explore the advantages of out-breeding.

There are a number of films and practical protocols on the SAPS website www.saps.org.uk to study pollen, its role in reproduction and its link with hay fever in more detail.

*Further activities*

Soaked white icicle radish or broad bean seeds provide younger students with independent, observational homework (over 4–6 weeks). Each student needs a jam jar and a roll of thick, absorbent paper, ensuring the seed is clamped to the side of the jar by the paper. The paper

sits in 2 cm of water and acts as a wick. Ask students to keep diaries, supported by drawings, for the whole life cycle. For older students, this could be set up as a demonstration and shown each lesson with students making their own notes to add to ones from the previous lesson. Photographs could be taken and put on Google Classroom or similar sharing platforms. Students need to be able to label the main parts of a seed and appreciate its subsequent growth. Reinforce here the emergence of the radicle first and then the plumule.

*Enhancement activities*

Students might consider how fruits are formed without seeds (e.g. seedless grape, satsuma). (These are generated by spraying with hormones that stimulate fruit production without prior fertilisation.) They can deduce that the normally prerequisite stage of fertilisation has been bypassed and the resulting fruit, while popular with consumers, is of no use in producing another generation.

With more advanced students, illustrate the starch food store in seeds and demonstrate the role of the (starch-digesting) enzyme amylase, using halved, soaked barley seeds placed with the outside in contact with starch agar in a Petri dish. This can also be done with broad beans, halved and placed surface downwards on the surface of the starch agar. After 24-48 hours at room temperature, flood the dish with iodine solution. The zone around each grain remains clear while the iodine on the rest of the starch agar is blackened. Ask students to account for the lack of starch in the clear zone. Eye protection is needed when handling iodine solution.

Introduce students to a range of seeds, fruits and vegetables. Many students do not realise how many of their foods come from plants, and this is an opportunity to make this clear. Show students multigrain bread, rolls with poppy seeds and mustard with wholegrain mustard seeds. Help students to appreciate that chickpeas can be ground to make flour and humous. Have a range of beans to show students along with various cans of beans, including kidney beans, baked beans and mixed beans. Get students to appreciate the plants and plant parts that are used for popcorn, sweetcorn and tortillas.

Allow students to explore seeds and introduce some seeds more familiar to students from different cultural backgrounds, such as coriander seeds, cardamom seeds, black cardamom seeds, chili seeds, onion seeds, chia seeds, seeds in various types of gourd, fenugreek seeds, chickpeas, nigella seeds, pomegranate seeds and dill seeds.

*Working scientifically*

How do particular seeds fall? Ask students to use dandelion or sycamore seeds (technically, fruits) in order to examine the relationship between height above ground and rate of falling. Ask them which variables (mass, shape, etc.) might affect the rate of fall. Data can be entered into a spreadsheet for further analysis. Model seeds can be made to test ideas further. Ask them why a slower rate may be an advantage to the plant producing the seeds. The video clip of 'Earth Unplugged' exploding cucumbers (https://www.youtube.com/watch?v=wOIHzl2h9a8) is an excellent clip to show seed dispersal by explosion.

**Examples of animal sexual reproduction**

The idea that most animals reproduce sexually as a result of the production of specialised gametes needs reinforcing; the male gametes are spermatozoa (singular: spermatozoon), abbreviated to sperm; the female gametes are ova (singular: ovum). Meiosis is the cell division that produces the gametes (see Chapter 2).

Students can be supported in discussing the reasons for sexual reproduction, particularly mammalian reproduction, which is technically more complex than asexual reproduction. Encourage them to deduce that it requires more energy and specialised organs that produce gametes, and also results in fewer offspring in a population. The crucial advantage is that individuals are slightly different from either parent and from other offspring of the same parents. In a changing environment some of these individuals may be better adapted and able to exploit new resources or colonise new areas. An organism's 'fitness' for a particular environment is a useful concept since it links environmental features and the organism's individual characteristics (see Chapter 9).

*Specialised sex cells, courtship and fertilisation*

Students should appreciate that most species can reproduce sexually, even those that also reproduce asexually. Examples might include species on a coral reef, including invertebrates

such as sea anemones, corals and jellyfish – e.g. see filmed sequences from *Malice in Wonderland* (1994), available from BBC Active Video.

Such sequences present visually the specialised sex cells (gametes), one from each parent of the same species, which join to form the first cell (zygote) of the new individual. Examples should also show that there are some species where individuals are able to produce both male and female gametes; these are described as hermaphrodites (e.g. earthworms and many molluscs, such as snails and slugs).

By providing stimulating materials and sources of information including texts, images (both photographs and diagrams), data and video clips, your students can be encouraged to study the life cycles of certain animals in more detail (e.g. fish, frog):

- Discuss how eggs are fertilised externally/internally, pointing out the numbers of eggs that are fertilised at any one time. Students can be helped to think why species with internal fertilisation typically produce fewer offspring than do species with external fertilisation.
- Ask students to identify any pattern across different species in the relationship between the number of eggs, whether fertilisation is internal or external, whether the period of post-fertilisation internal development is brief or extended, the extent of parental care once offspring are no longer inside the mother, and the chances of offspring surviving to maturity.

Video sequences can helpfully illustrate courtship patterns, as well as the act of copulation and fertilisation, in a variety of animals, such as amphibians, fish and birds. BBC *Trials of Life* (1990) has two episodes, *Courting* and *Continuing the Line*, which illustrate a variety of breeding activity (BBC Active Video) and there are plenty of more recent example that can easily be accessed on-line.

*External versus internal development; aftercare*

Discuss the advantages of retaining the young offspring in the body of a parent; this is usually the female – but note, for example, the use of the male pouch in seahorses (students can search for a video of this, e.g. on YouTube). You can draw on students' own experiences of a variety of newborn pets.

*Further activities*

Students can discuss the extent to which humans and other mammals provide for emotional as well as physical needs of their offspring.

The advantages of sexual reproduction can also be seen as the disadvantages of asexual reproduction, where only a stable environment will ensure reproductive success. Students can compare and then summarise in a table the advantages and disadvantages of both types of reproduction.

## 7.3 Human reproduction and sex education

### Legal framework for sex education

Countries, both within the UK and beyond, vary greatly in the role that they expect schools to play in sex education. In England a helpful summary of the legal framework is provided by a House of Commons Briefing Paper (Long, 2019). A DfE document (DfE, 2019) provides the statutory guidance. The key points for secondary schools in England are that from September 2020:

- All such schools (whether state or independent) need to teach age-appropriate 'relationships and sex education'.
- Schools must ensure that they comply with the relevant provisions of the Equality Act 2010, under which sexual orientation and gender reassignment are amongst the protected characteristics.
- Schools should realise that students may need support to recognise when relationships (including family relationships) are unhealthy or abusive (including the unacceptability of neglect, emotional, sexual and physical abuse and violence, including honour-based violence and forced marriage).
- Parents still have the right to withdraw their children from sex education outside of National Curriculum science but all children, even if their parents disagree, are

entitled to receive one term's sex education in the three terms before they reach the age of 16.

As a science teacher, you are likely to be involved in teaching aspects of sex education whether or not you are a biology teacher, though the extent to which this is the case varies from school to school and between countries. In some schools, anything to do with 'relationships' is dealt with outside of biology lessons, often in a programme to do with PSHE ('Personal, Social and Health Education or 'Personal, Social, Health and Economic Education') issues. You must be aware of your schools' policy on sex and relationship education and stick to it! Do not invite in outside speakers or take students out on visits unless you have cleared this with a senior colleague – such as the appropriate Head of Year.

Your own classroom relationships with students are important for being effective in this sensitive area, and you should not be deterred from encouraging, wherever possible, open and frank discussion about issues, though never about particular personal circumstances. Where a student might approach you to share some personal information, you should use your professional judgement about keeping confidentiality, while at the same time *never promising* confidentiality. You always provide details of alternative (i.e. non-school) sources of advice and of treatment and your school may have a school nurse – who can be a tremendous asset.

Developing your own sensitivities to the personal circumstances of individual students and their families is important in your class work, and teaching this topic in particular may expose you to potential signs of child abuse. Identification is often not easy and, in addition to more obvious physical signs such as bruises, burns, bites and scars, a general indicator is often neglect. Indicators of sexual abuse include sexually transmitted infections, recurrent urinary infections, inappropriately sexually explicit behaviour, young students with too much sexual knowledge, sexually abusive behaviour towards other children and pregnancy. Emotional abuse is often indicated by low self-esteem, lethargy or attention-seeking behaviour, and delayed social development. As a teacher, always take steps to share any concerns with the designated member of the school staff – the School Child Protection Officer (SCPO) – writing down dated, factual details as well as reporting them orally.

**Previous knowledge and experience**

Students will almost certainly have been taught something about aspects of human reproduction and relationships, at primary school and/or in their families, but research shows such teaching is often patchy. In addition, at this age, students' physical and emotional developments are highly variable and this partly determines the extent to which they will have absorbed or questioned information given earlier on. There will be differences in the provision from different homes, social and cultural backgrounds, different primary schools and different teachers within any school.

National surveys to find out what young people really want in this area generally find that teaching is often provided too late. Targeting younger secondary students is therefore important. Boys generally have lower levels of knowledge of reproduction, contraception and contraceptive services than do girls, and so a school needs to take steps to ensure that this is rectified. Girls often say that they want more discussion and explanations in order to counterbalance an overemphasis on biological facts. Clearly boys require this too.

Educational videos and other material in this area of the curriculum should be chosen with care for their appropriateness and always be used in such a way that there is time for reflection, clarification and discussion of sexual issues in the classroom. Many schools have a system where parents are able to come in and see materials that are used for teaching sex education and meet staff who will be teaching it.

**A teaching sequence**

As a science teacher you can do a great deal of good when teaching sex education and you have the advantage when teaching in this area that your students are not likely to forget most of what you teach them! Many teachers initially find it embarrassing to teach sex education. However, this generally eases over time and science teachers have the advantage that they can communicate a lot of extremely valuable information even if not everyone, in the first year or two of teaching, feels comfortable at handling discussions in this area. For younger secondary students you are aiming to extend knowledge about human reproduction and to relate the ways the body changes in adolescence to your students' developing understanding of human reproduction, growth and the menstrual cycle.

Use terminology with care. In mammals, including humans, the fertilised ovum is called a zygote and it develops to form an embryo and subsequently the fetus. Students should

appreciate the size and approximate number of gametes produced by males and females, and older students should identify the similarities and differences between the structure of an ovum and a sperm. Try to assess and then extend your students' present knowledge of puberty, anatomy, conception and its prevention, the development of relationships and the medical and other problems associated with sexual involvement early in life.

Bear in mind that some students may have the technical vocabulary but their actual understanding can be poor. They need help in knowing where various anatomical parts are located as well as what the parts do. Aim to make your audience feel comfortable about not knowing things, while at the same time making it possible for them to find out. Laughter and *appropriate* joking can help to make everyone feel less awkward and more comfortable while at the same time enabling you to address every question seriously and with respect.

**Physical and emotional changes at puberty and during adolescence**

Between the ages of 10 and 14, most young people will be entering puberty and will be interested in hormones, how they will be affected by them, the menstrual cycle, wet dreams, erections, fertility, pregnancy (including how it can be avoided) and safer sex. They may also be wondering if their physical development is 'normal'. They may want to know about the difference between sexual attraction and love and whether it is normal to be attracted or in love with someone of the same sex. They are likely to be asking questions about relationships, when is the right time to have sex and where they can get more information if they need it, including the best websites, confidential services etc. Ascertain what materials your school uses for teaching in this area and if you want to use different ones, check with your Head of Department first.

An exploration with your students of how males and females differ physically should enable you to summarise the key changes at puberty. A useful ice-breaking activity might be to place each key point describing a secondary sexual characteristic (e.g. breasts, wider hips, facial and body hair, voice changes, stronger body smell) on a separate card; small groups of students can then discuss and arrange the cards under one of the two headings 'males' and 'females'.

Stress the wide variation in the age of onset of puberty and the generally earlier age of onset for girls and the fact that puberty doesn't happen at once but takes place over a number of

years. Help students understand that changes in hormone concentrations result in the development of secondary sexual characteristics and emotional changes at puberty. Explore possible reasons for the earlier onset over the last 50 years (better diet, fewer infectious diseases).

**Male and female reproductive systems**

Many younger students tend to have muddled ideas about how many urinary, genital and defaecatory orifices people have (females have three, males two) and often both boys and girls do not know from where a girl urinates. Students should understand that the urethra has a dual function in the male. The similarity in sound and spelling of 'ureter' and 'urethra' can also be confusing for many students. In the female the urethra has only one function, which is in connection with the urinary system.

Older students need to know the structure and function of the parts of the urinogenital (= genitourinary) system; younger students can be presented with a reduced list of key terms or simplified terminology. It is generally best to provide accurate, but unlabelled, line diagrams that students can then label themselves. This activity can be extended into a card-sorting/matching exercise in which students are provided with key names on one set of cards and a second set of cards with the key functions of the parts.

Help students to understand that the erectile tissue of the penis becomes firm as it fills with blood when the penis is stimulated either manually or indirectly through specific visual or other stimuli. Some male students may need reassurance about the normality of wet dreams and masturbation. The dual role of the urethra in the male will need some clarification: glands at the base of the bladder produce secretions that wash away the urine in the urethra (urine can deactivate sperm).

Masturbation for female students also needs mentioning, particularly as it is sometimes omitted from school textbooks. Indeed, the clitoris is sometimes rendered invisible by being absent from diagrams as well as absent in any discussion about structure and function – see Cohut (2018).

Muscle rings in the sperm duct squeeze the sperm along the passage. This action can be simulated by pushing toothpaste along in its tube, which is similar to peristalsis in the intestinal tract. Further glands mix nutrient secretions with the sperm to form semen. Ask

students why this is necessary. Illustrate the volume of the ejaculate: about one teaspoon of semen is produced at ejaculation. The prostate gland is often incorrectly referred to as 'prost*r*ate'! It is frequently enlarged in older men and students can deduce the effect of any enlargement on the frequency of and difficulty in urination.

Since the female reproductive organs are largely invisible, and therefore particularly mysterious, ask students (male and female) to site the position of the ovaries by placing their fingers on their own abdomen. To do this, suggest they feel for the front points of the pelvis and move in towards the navel an inch or so. Ask students to feel the tip of their nose with a forefinger. Say that this feels rather like the cervix, the ring of muscle that closes the lower end of the uterus where it joins the vagina. Use a model of the human torso, and a skeleton, to help pupils understand the 3D arrangements of the key reproductive organs, since diagrams are presented as 2D arrangements, which can be confusing.

There is a very small hole in the cervix to permit sperm to enter; the cervix dilates during labour; check that students understand why. Students can estimate the size of the adult vagina (which they often conflate with the vulva) and the size of the adult, non-pregnant uterus. For comparison use a medium-sized inverted pear (about 10 cm long) and tilt it backwards slightly to illustrate the angle of the uterus with respect to the vagina.

Point out the need for a good blood supply to the uterus and explore why this is so. Ask students to suggest how long the egg takes to be moved from the ovary to the uterus (24-48 hours). The vagina is a muscular tube with sensitive nerve endings and glands that can secrete mucus. Explore with your students the reasons for these.

Sperm swim towards the oviducts aided by movements of the female reproductive system. After an hour they no longer swim but they can survive in the uterus or oviducts for three or even more days. Explore with your students why it is important to be aware of this and how the timing of ovulation can influence the chance of fertilisation.

One way to address questions from students is to provide them with a box in which they can place their questions at the end of a lesson. Read the questions away from students and deal with as many as possible the next time you teach the students. This can be extended into an Extended Writing Activity – an Agony Column in a teenage magazine, where *you* provide stimulus questions/issues that require answering. Students then write a response to provide factual and supportive answers. The extent to which you share this writing across the class should be carefully considered.

Use video sequences and pictures to illustrate and discuss the processes which lead to fertilisation and implantation of the zygote. Students can devise flow diagrams (electronically or on paper / cardboard) to represent the key events leading to implantation. The emotional as well as the physical aspects of sexual relationships should be addressed through discussion, though only if the school sex education policy allows for this.

Textbooks and other teaching materials sometimes assume intercourse is heterosexual and that sexual activity is penetrative (vaginal) intercourse. Such texts can also be sexist since intercourse is sometimes presented only from a male's point of view. Ejaculation by the male is frequently mentioned; orgasm in the female less often. Accounts of loving relationships, or indeed the passions or pleasures associated with sex, are all too often notable by their absence. It is important to create a balance between an anatomical account and a psychological and emotional account. Again, you must act in accordance with your school's policy.

Finally, you can take the opportunity to review fertilisation in terms of fusion of male and female nuclei and discuss how this results in characteristics being passed from parents to offspring (see Chapter 8). Twin and multiple pregnancies are always of interest to young people: provide some statements containing some correct and incorrect explanations and ask them to select the correct explanations of how identical and non-identical twins can arise. Factual examples of conjoined twins and how they arise is also of interest to students. There are always examples to share with students. This is also an opportunity to establish that, generally, humans have one offspring at a time, and that the reproductive system and post-natal care, including breastfeeding, have evolved to make sure that the one offspring is as likely as possible to survive.

*Enhancement activities*

Encourage students to speculate about different causes of infertility in men and women, linking their ideas to the structures and functions of the reproductive systems, e.g. low sperm counts, blocked oviducts, infrequent ovulation. This should include information on chlamydia, cervical cancer and testicular cancer. Students could be encouraged to find out more about the technological treatments now available, and some of the social and ethical issues surrounding the provision of fertility clinics.

**Menstruation and the control of fertility**

Menstruation tends to remain a taboo subject in our society, which is unhelpful to an adolescent girl for whom it is acutely realistic. The physical, emotional and practical aspects of 'periods', particularly in the school setting, do very little to reassure girls of the positive experiences of becoming a woman. When young people are asked 'What is menstruation?', research has shown that over one-third of 13 to 14-year-old students do not mention menstrual fluid, and when questioned specifically, the actual source of the menstrual blood as the shedding of the uterine lining is frequently misunderstood. Try to aim for a balance between a purely physiological approach and a more personal account that goes some way to acknowledging the reality of this event for half the school population!

Many schools have the 'Red Box Project' to provide free menstrual products within school. This is particularly important in ensuring that girls do not miss out on education because they cannot afford sanitary protection. It also provides an opportunity to examine how girls and women in other parts of the world deal with their periods. This can make cultural links more explicit.

The teaching and associated discussion of the natural and artificial methods of preventing pregnancy (i.e. birth control or 'family planning') frequently falls to the science teacher. Much of what follows is for older students (14 years plus) so be guided by your school sex education policy and mindful that the use of artificial contraception is not acceptable to all adults or young people. The health risks, both physical and emotional, of under-age sex should always be discussed. Students need both general and local guidance about how to seek information and advice (e.g. 'drop-in sessions' with a school nurse or at a youth clinic) and how to buy items or to access the particular medical services that supply them (the diaphragm, intrauterine device, contraceptive pill and the 'morning after' pill, usually referred to as 'emergency contraception'). In relation to fertility, you may wish to point out that an unfertilised egg will not survive for more than three days, although sperm can remain alive for a day or two longer. Challenge any idea that fertilisation cannot take place if male ejaculation takes place outside of the vagina, and explain why.

Ask older students in groups of three to five to make a PowerPoint presentation, advertising a particular contraceptive. They should consider how the contraceptive works, for whom it

would be most useful, and present the chief risks. Alternatively, using desk top publishing, small groups of students might produce a leaflet concerned with one type of contraceptive.

*Social and ethical issues*

The control of fertility raises a number of points of social and ethical concern. The following technologies provide opportunity for young people to think about the links between the science and society:

- Artificial insemination (AI) of a woman with her male partner's sperm can allow an infertile couple to have a child without a third party being involved. If the male cannot produce fertile sperm, sperm from a donor may be used (AID). You can explore with students how this might be similar to, or different from, adoption of a child by the couple. Ask them to make a list of issues that might be of concern with AID.
- *In vitro* fertilisation (IVF) ('test-tube babies') provides a particularly useful discussion topic. It is used to treat women whose ovaries are functioning but whose oviducts are blocked, or where sperm motility of the partner is poor. The woman is treated hormonally to super-ovulate. Ask students to consider advantages and possible disadvantages of IVF.
- IVF for same-sex couples or for single women wishing to have a baby could be discussed.

**Sexually transmitted infections**

A detailed study of sexually transmitted infections (STIs) may best be done within the topic of microbiology (see Chapter 12). The modes of transmission should be considered for the six commonest STIs: chlamydia (bacterial), genital warts (viral), gonorrhoea (bacterial), genital herpes (viral), hepatitis B (viral) and Human Immunodeficiency Virus – HIV (viral). Other STIs that might be considered include syphilis (bacterial), pubic lice (crustacean), urethritis (bacterial), thrush (fungal), bacterial vaginosis and trichomoniasis (protozoon).

Students should learn how STIs are passed on to another person and how they are best avoided. Offer the reassurance that, with early detection, almost all can be successfully treated. Aim to dispel any misunderstandings. Find out what your students do, or do not,

know about STIs; challenge prejudices about those who may catch an STI. Students need to know that nowadays people infected with HIV generally look as healthy as anyone else.

Human papilloma virus (HPV), sometimes called ‘genital wart virus’, can be passed from one person to another through sexual contact. Younger students (11 years plus) need to be prepared for the HPV vaccination programme, which is offered to all students in the UK, boys and girls. The programme is drastically cutting rates of cervical cancer.

Since the routes of transmission of STIs involve sexual contact, an important teaching objective is to raise students’ awareness about the need for safer sex. They should be informed about the risks of transmission through the mixing of body fluids, which include semen, vaginal secretions and blood. This may be best addressed when teaching about contraception so students can weigh up the ‘pros’ and ‘cons’ of the various contraceptives in terms of effectiveness in preventing transmission of STIs.

Schools may decide to invite health professionals into the classroom to support the teaching in this area, and SRE Advisors (Local Authority), Teenage Pregnancy Co-ordinators/Managers (NHS) or other personnel from GUM clinics can often provide expert help. There are good video sequences, too, though it is important to check that these are up to date and to plan carefully so students always have the opportunity to talk about the topics and issues that arise.

## 7.4 Human pregnancy

### Previous knowledge and experience

Students are likely to have met some of the processes of fetal development; some understanding of the role of the parents and childcare will also be present.

### A teaching sequence

Your aim is to extend students’ ideas about how offspring are protected and nurtured following the fertilisation of the egg through pregnancy and up to birth itself. Students should learn that the fetus develops within a membranous bag, supported and cushioned by amniotic

fluid. They should develop their understanding of the placenta: this supplies nutrients and oxygen to the fetus via the umbilical cord, and removes carbon dioxide and other waste products.

Students will need help in making the links with other important biology topics such as the circulatory system, so they can appreciate the route taken by nutrients from the mother's digestive system to the fetal brain and other tissues. They will need to link their broader knowledge of diffusion gradients to explain how oxygen, water and digested food pass from the mother's blood to the fetal blood in the placenta, and, in the reverse direction, how carbon dioxide and other waste materials leave the fetal blood and enter the maternal blood.

The frequent reality of miscarriage might be discussed.

Ask the students for which body organs the placenta acts as a substitute. Stress that fetal and maternal blood supplies are very close but completely separate. Students need help to appreciate that harmful substances can cross the placenta to the fetus and affect development.

The processes of birth can be summarised by students, using photographs and diagrams as illustration and alongside a flowchart that shows the main stages of labour. Describe how the newborn baby obtains nutrients and oxygen vital for survival and growth. The many excellent videos and photographs that are available should always be used with care, to avoid embarrassing or distressing those students who may find that some sequences make them feel squeamish or faint. Always be sensitive, where pregnancy and birth are concerned, to their impact on young people and their families (e.g. adoption, miscarriage or neonatal death).

Students should also be helped to understand the importance of breast milk in providing antibodies to protect against infection from common microorganisms. Be aware that some cultures do not encourage breastfeeding. Students could find out more about newborn reflexes, such as head turning when a newborn's cheek is touched.

**Further activities**

The whole topic of pregnancy, birth and neonatal care provides good opportunities for students to get to know more about the medical, maternity and welfare services provided by GPs and other parts of the NHS, as well as parenting issues. A school nurse, local midwife or health visitor may be helpful in providing your class with accurate information and detail

about Caesarean sections, induction of birth, breech births, modern monitoring techniques, good-quality childcare and so on. In advance of a session with a visitor, let students draw up a list of possible questions they might ask.

You can help students prepare for talking with professionals about health-related aspects with a range of suggestions (e.g. Why are pregnant women offered additional iron supplements? Why can obesity be a health problem in pregnancy? Do fathers have to watch the birth? What is a good role for a new father?). Students can find out more about the composition of breast milk and the value of the colostrum that is produced immediately after birth as the first feed, and appreciate why some women use bottles for feeding.

### Social and ethical issues

Abortion is a particularly sensitive issue that needs careful handling, and with due consideration for some religious and cultural groups. Again, consultation of your school's policy is essential here, as is discussion with relevant staff. You should endeavour to remain neutral at all times when presenting the debate and allow your students to try to work out for themselves the position they may wish to adopt. Be particularly cautious about how you might use the materials and resources produced by some of the key pressure groups.

Cloning livestock embryos is an important technique in animal breeding. Animal clones are genetically identical individuals formed by taking a body cell, such as a skin cell, and removing its nucleus which is then planted into an egg cell that has had its nucleus removed. The zygote that is formed grows into a ball of cells, as was the case in Dolly the sheep (Figure 7.2). The ball of cells is planted into the prepared 'pregnant uterus' of the recipient. Ask students to summarise the advantages and potential issues of such processes in animal breeding.

**[Insert Image – Figure 7.2: Free photograph]**

**Figure 7.2** Dolly the sheep – the first mammal to be cloned from an adult cell.

There have been claims that various research groups have cloned humans but none of these have been substantiated and accepted by the scientific community. From a technical perspective, cloning humans and other primates is more difficult than in other mammals. One reason is that the spindle proteins, which pull the chromosomes to opposite ends of the cell

during cell division, are located very close to the chromosomes in primate eggs. Consequently, removal of the egg's nucleus to make room for the donor nucleus can unintentionally remove the spindle proteins, halting the cell division process. Clearly, human cloning would raise huge ethical issues and students may enjoy discussing these.

## Equipment notes

### *Asexual reproduction in plants and animals*

**Bread mould cultures** require moistened pieces of stale bread in dishes exposed to the air for 24 hours. Keep the bread slightly moist to prevent it drying out, and cover with a glass jam jar to keep it humid. Ensure that students do not lift the jar.

A **cell suspension of actively growing yeast cells** can be made at the bottom of a small flask, using 8 g fresh baker's yeast and 10 g glucose (or cane sugar), made up to 200 $cm^3$ with distilled water. Plug with cotton wool and leave in a warm room (22 °C) for 20 minutes before use with the class. Always pre-test culture conditions before the lesson to ensure that cell division is taking place. In a small pipette, transfer one drop of the culture to a microscope slide with a small amount of methylene blue stain and cover with a coverslip. Use methylene blue for staining living cells as follows: 1 g methylene blue; 0.6 g sodium chloride; 100 $cm^3$ distilled water. Methylene blue is harmful.

### *Sexual reproduction in plants*

A specially selected mutant **rapid-cycling brassica** provides a versatile and easily maintained resource to develop students' understanding of the life cycle of a flowering plant in 4-6 weeks, when grown under a specially constructed artificial light bank in the school laboratory. Its versatility lies in the opportunity to study its life cycle at any time of the year; it can be 'grown to order' to obtain germinating seedlings, pre-flowering or flowering plants for a particular teaching day. There are numerous investigative ideas available for teachers as part of extensive resource packs. Contact Science and Plants for Schools (SAPS).

**Starch agar plates** are made up as follows: make a starch suspension with 10 g starch and 1 $dm^3$ distilled water. To do this, mix a little of the starch with cold water; bring the rest of the

water to the boil; add the starch mixture to the boiling water. To make up the iodine solution use 3 g iodine crystals and 6 g potassium iodide. Dissolve the potassium iodide in 200 $cm^3$ distilled water, add the iodine crystals and make up to 1 $dm^3$ with distilled water. Make up 24 hours before it is to be used to allow the iodine to dissolve fully. Iodine crystals are harmful; use gloves and eye protection when handling.

*Sexual reproduction in animals*

Using a scale of 1 : 200, students can make scaled two-dimensional models of an egg and a sperm. To do this for the egg, draw a circle with a diameter of 20 cm. For the sperm draw a head diameter of 0.8 cm, and overall length including head of 10 cm. The actual dimensions are indicated on Figure 7.3.

**[Insert Image – Figure 7.3]**

**Figure 7.3** Actual dimensions of human egg and sperm. (Based on *Nuffield Coordinated Biology* (1988), Figure 19.1b, p. 245. Harlow, Longman.)

**Local organisations**

AIDS support services

Department of Genito-Urinary Medicine (GUM)

Family Planning Clinic and/or Young Person's Clinic

Health Promotion Centre

Lesbian and Gay Communities Resource Centre

Rape Crisis Centre

**National organisations**

**AVERT:** Information and education on HIV and AIDS: www.avert.org/.

**Brook:** Advice and information for under 25s within the UK on STIs/contraception/relationships/pregnancy: http://www.brook.org.uk.

**Sex Education Forum:** Collaborative network, representing many organisations in England, all involved directly or indirectly in the provision or support of sex and relationships education (SRE). It provides SRE resources, web materials, and training: https://www.sexeducationforum.org.uk.

## References and further reading


Callahan, G. N. (2009) *Between XX and XY: Intersexuality and the Myth of Two Sexes*. Chicago: Chicago Review Press.

Cohut, M. (2018) The clitoris: What is there to know about this mystery organ? *MedicalNewsToday*. Available at https://www.medicalnewstoday.com/articles/322235.php.

Department for Education (DfE) (2019) *Relationships Education, Relationships and Sex Education (RSE) and Health Education*. London: Department for Education. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805781/Relationships_Education__Relationships_and_Sex_Education__RSE__and_Health_Education.pdf.

Halstead, J. M. & Reiss, M. J. (2003) *Values in Sex Education: From Principles to Practice*. London: RoutledgeFalmer.

Long, R. (2019) *Relationships and Sex Education in Schools (England).* London: House of Commons Library. Available at https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06103.

Reiss, M. J. (2018) Reproduction and sex education. In: Kampourakis, K. & Reiss, M. J. (Eds) *Teaching Biology in Schools: Global Research, Issues, and Trends*. New York: Routledge, pp. 87-98.

Reiss, M. J. (2019) Thinking like a fox: Queering the science classroom when teaching about sex and sexuality. In: *STEM of Desire: Queer Theories and Science Education*, Letts, W. & Fifield, S. (Eds). Leiden: Brill | Sense, pp. 255-267. DOI: 10.1163/9789004331068_015.

Stanger-Hall, K. F. & Hall, D. W. (2011) Abstinence-only education and teen pregnancy rates: why we need comprehensive sex education in the U.S. *PLoS ONE* 6(10): e24658. https://doi.org/10.1371/journal.pone.0024658.

Yip, A. K.-T. & Page, S.-J. (2013) *Religious and Sexual Identities: A Multi-faith Exploration of Young Adults*. Farnham: Ashgate.