P I N E I N T E R M E D I A T E V E R S I O N

1. In temporate regions of the northern and southern hemispheres there are forests of cone bearing trees, known as conifers.	FORESTS FROM THE AIR	
2. One group in particular, the pines, is especially familiar and comprises one of the most extensively traded crops in the world.	PINE FOREST FROM THE AIR	
2a. Pollen plays an important role in pine reproduction and we know that it is released from small cones, called pollen cones.	REAL CONE RELEASING POLLEN	
	Pollen Formation	
VOICE	IMAGES	REEL
3. The pollen cone consists of many small scale-like parts arranged in numerous spirals.	ANIMATION: ENTIRE CONE Cone model rotating	
4. Each scale in a single spiral is attached to the central cone axis.	POLLEN CONE: single spiral	
5. On the underside of each scale there are two spore sacs.	MICROSPOROPHYLL: rotation	
6. Each is covered by several layers of cells.	MICROSPOROPHYLL: outer layer epidermis sliding off to the right and left	
7.	MICROSPOROPHYLL: remov microsporangium	
8.	MICROSPORANGIUM: remove all external layers	
9. In the centre, there is a mass of spore-producing cells	MICROSPORANGIUM: slice i sporocytes	
10.. Each nucleus contains two sets of chromosomes, one from each parent.	MICROSPORANGIUM: move in on to sporocyte cells	
11.	SPOROCYTE CELLS: callose	

12. The nucleus inside each cell divides twice by the process of meiosis to form four daughter nuclei, each with one set of chromosomes.	MICROSPOROCYTE: INSIDE Splitting open the cell and rotating.	
13.	MICROSPOROCYTE: meiosis Nucleus dividing	
14. Each nucleus becomes surrounded by a wall that begins to enlarge at two points.	MICROSPOROCYTE: four nuclei	
15.	MICROSPOROCYTE: wall formation	
16.	MICROSPORE: appearance of wings	
17. Continued growth results in spores with two , gas-filled wings**.**	MICROSPORE: wing enlargement	
18.	MICROSPORES: separation	
19. The spores increase in size and a thick wall forms around the cell inside.	MICROSPORE: intact, exterior view <u>Motion:</u> camara swings around to one microspore	
20.	MICROSPORE: cut apart	
21. The spore cell soon divides three times, forming male tissue. The male, together with the surrounding wall, is called a pollen grain.	MICROSPORE: mitotic divisions	
22.	POLLEN GRAIN: halves coming together	
23. A final deposit of wall material completes the formation of the pollen grains and they are released when the spore sac opens.	POLLEN GRAIN <u>F</u>inal deposit of sporopollenin	
24.	POLLEN GRAIN: release Sporangium opening	

25. The pollen grains are soon caught by air currents enabling some to reach ovule cones.	REAL SHOOT TIP WITH CONE Pollen being blown away.	
SUMMARY • Pollen cones contain scales with two spore sacs on their lower surface.	CONE SCALE showing two microsporangia	
• Spore sacs contain fertile tissue that divides by meiosis to form spores.	MEIOTIC DIVISION Meiosis followed by spore walls forming	
• Spores enlarge and form wings.	WINGS FORMING	
• Each spore cell develops into a pollen grain, containing male cells inside a tough protective wall.	SPORE CELL Three divisions	
• Pollen grains are released from the spore sac and dispersed by the wind.	SPORANGIUM opening or live shot of wind blowing pollen out of pollen cone.	

	The Ovule Cone and Pollination	
VOICE	IMAGES	REEL
1. Seeds play an important role in the reproduction of pine and we know that they are released from large, woody cones. A curious fact is that these cones take two years to mature.	OLDER SHOOT Close up of woody a cone.	
2. In the spring of the first year, they are small and soft. At this time they contain ovules and are therefore called ovule cones	YOUNG SHOOT TIP, YOUNG OVULATE CONE Young stem with a cluster of 1st year ovulate cones	
	(First growing season)	
3. The intact ovule cone consists of numerous spirally arranged scales**.**	**ANIMATION** FADE OVER FROM REAL TO MODEL CONE	
4. Each scale in a single spiral is firmly attached to the central cone axis.	OVULATE SCALES: entire cone, then removing all but one spiral of ovuliferous scales.	
5. The upper surface of a scale contains two ovules. Each ovule has an outer protective jacket**.** A tube-like opening in the jacket is covered with a sticky secretion. Beneath the jacket there is a fleshy spore case containing a fertile cell with two sets of chromosomes.	SINGLE OVULIFEROUS SCALE: Fly around to show top surface of ovuliferous scale. Move in close. Move up to micropyle Add stick drops SLOW DOWN: Remove integument covering. Remove sporangium covering	

6. When the cone is ready to receive pollen, the scales separate, exposing the ovules inside.	OVULATE CONE: Scales parting.	
7. Carried by air currents, some pollen grains are forced between the scales and fall down toward the ovules .	POLLEN GRAINS: Pollen arriving in the sky, then being blown up against the ovulate cone Pollen falling down inside the cone	
8. Some of the pollen grains come into contact with the sticky surface of the tube.	OVULE: Micropyle with sticky drops. Pollen arriving and sticking to drops.	
9. The spore case now releases a fluid called the pollination drop. As this fills the tube, it pickes up the pollen grains.	OVULE: pollination drop forming. Ovule opened up to see pollination drop rising in micropyle. Pollen grains on surface, one going into the drop and up micropyle.	
10. The pollination drop soon moves back up the tube, taking the pollen grains to the surface of the spore case.	OVULE: pollination drop receding. Pollination drop shrinking down to surface of megasporangium. Pollen grains on sporangium surface.	
11. At this time, the tube withers and closes, sealing the pollen grains inside the ovule.	OVULE: closure of the micropyle Camera pulls back; lid back on the integument. Micropyle arms withering.	
12. The scales of the cone now grow together, sealing the ovules inside a tough protective barrier	OVULATE CONE: closing	
SUMMARY • On the upper surface of an ovule cone scale there are pairs of ovules.	OVULIFEROUS SCALE To show pair of ovules	
• An ovule has an outer jacket with a tube that leads to a spore case inside.	SINGLE OVULE To show integuments and micropyle	
• Pollen is captured by the tube and carried to the spore case by the pollination drop.	OVULE WITH POLLINATION DROP To show pollination drop	

	The male and female Tissue	
VOICE	IMAGES	REEL
13. Inside the ovule, on the surface of the spore case, the pollen grain begins to swell and form a tube-like growth.	MEGASPORANGIUM Spore case lid comes off; pollen grains on surface; move in close	
14. A small male cell remains inside the pollen grain while the tube cell directs the growth of the pollen tube.	POLLEN GRAIN Surface of pollen tube; Interior; tube growth commences into lthe sporangium.	
15. The male soon divides and the two cells move into the pollen tube.	GENERATIVE CELL: the generative cell dividing Interior of pollen grain-tube to see cells. Put exterior back on to p.grain-tube.	
16. Deep inside the spore case, the fertile cell now divides twice by the process of meiosis**.** The result is four, thin walled spore cells, each with one set of chromosomes.	MEGASPORANGIUM: Cut-away of sporangium. Camera swings to middle to see sporocyte cell.	
17.However, three of these degenerate.	MEGASPORES: three shown degenerating	
18. As the surviving cell enlarges, its nucleus divides many times, but no walls are formed. It is now the end of the first growing season.	MEGASPORE NUCLEUS: Megaspore becoming transparent. Repeated mitotic divisions Surface of megaspore put back.	
	The second growing season	
19. With the passing of winter, growth resumes and walls are formed in what is now, the female tissue.	FEMALE GAMETOPHYTE Surface cut open Regular rows of cells Lid of megaspore put back in place.	
20. At one end of the female, several pores appear on the surface. Each of these leads down to an egg case.	ARCHEGONIA: Fade in of 2-3 archegonia at Swing around to full frontal view.	

21.	ARCHEGONIUM: Fade away of female tissue Three archegonia shown in 3D, front and then side view of one **TRY TO BRIGHTEN UP EGG CASES.**	
22. At the entrance of an egg case there are one-to-two rings of neck cells. Inside, there is a large basal chamber containing a single egg cell.	ARCHEGONIUM highlighting parts: Neck, neck cells Venter, x-ray of egg inside Venter surface view Return female tissue Return lid to sporangium. Whole ovule on scale.	
SUMMARY • The pollen tube carries the male into the ovule spore case. .	GROWING POLLEN TUBE with two male cells and tube cell	
• The ovule spore case forms only one functional spore.	SINGLE MEGASPORE Cut away to show surviving m.spore	
• This spore cell divides to form female tissue	DIVIDING OF MEGASPORE SPORE	
• The female tissue contains several egg cases at one end	ARCHEGONIA AT ONE END	

	FERTILISATION	
VOICE	IMAGES	REEL
23. Early in the second year, the pollen tube has grown through the spore case toward the female tissue.	POLLEN TUBE: Ovules on scale Camera moves in Lid to sporangium comes off A pollen tube heading towards one archegonium	
24. As the pollen tube approaches an egg case, the male cell divids to form two sperm.	SPERM CELLS: Close up of tube tip, x=ray to show division of spermatogenous cell	

25.	POLLEN TUBE: Pollen tube entering concavity containing neck cells. Dissolve female tissue to see two neck cells and tube goint into them.	
26. Reaching the entrance, the tip of the pollen tube forces its way between the neck cells and into the egg.	POLLEN TUBE: Tube entering egg cell	
27. Several cells, including two sperm, are released. One sperm fuses wilth the egg nucleus, resulting in a cell with two sets of chromosomes.	FERTILISATION Tube nucleus, sterile cell and sperm cells entering egg. Sperm joins egg nucleus. Camera moves back into sporangium.	
28. Adjacent egg cases may also be fertilised if more than one pollen grain is present. . The female may therefore contain more than one fertilised egg.	MULTIPLE FERTILISATION: A second pollen tube seen going through sporangium and entering an archegonium concavity. Pull back.	
29. At the time of fertilisation, the ovule consists of several eggs inside the female, which sits inside the spore case. The male has grown through the spore case to reach the egg. This is all enclosed by an outer jacket.	OVULE: SLOW THIS DOWN !!!!!!! Three archegonia Female gametophyte (stop)megasporangium Pollen tubes, cut away integument, cut away pull back and lid of sporangium back.	
SUMMARY • The male cell divides to produce two sperm.		
• The pollen tube delivers the sperm to the egg cell.		
• The fertilised egg contains two sets of chromosomes.		
• Several eggs may be fertilised within a single female.		

	Embryo and Seed Formation	
VOICE	IMAGES	REEL
30. Protected inside the ovule, the fertilised eggs are now ready to form embryos. Each soon begins to divide.	OVULE: GOING INSIDE : SLOW DOWN Ovule on scale; move in and remove all covers to show zygote nucleus inside archegonium.	
31. When four nuclei are formed, they move to the base of the egg case.	FIRST AND SECOND DIVISIONS Zygote divisides twice. Nuclei migration.	
32. Further divisions now occur. Cell formation begins with the appearance of walls around the nuclei. The four cells at the very base will form embryos.	FOURTH & FIFTH DIVISION: Four nuclei divide twice 16 nuclei. Walls forming and differentiation of two sets of initial cells.	
33. The cells behind the embryos enlarge, pushing them out of the egg case .....and into the female tissue.	SUSPENSOR INITIALS: elongation taking place Showing the suspensors elongating within the archegonium	
34. The female tissue now proceeds to nourish the growing embryos.	SUSPENSORS PUSHING OUT OF ARCHEGONIUM Apical initials/embryos in female tissue	
35.	CORROSION CAVITY FORMING	

36. The four embryos soon separate and each is pushed further into the female tissue.	EMBRYOS Suspensors pushing four embryos into the female gametophyte.	
37. Intense competition for nutrients and space results in only one embryo surviving.	EMBRYO COMPETITION: Embryo competition. Growth of all four embryos with one enlarging and the others diminishing in size and lagging behind.	
38. Embryos in adjacent egg cases proceed through the same stages of growth and competition. However, only one survives to occupy the forming seed.	ADJACENT ARCHEGONIA: three archegonia, the embryo of one dominating those of the others	
39. This develops a stem tip surrounded by a circle of seed leaves.	COTYLEDONS: development Appearance of tiny bumps around apex.	
40. The embryo now enlarges, forming a stem....and a root cap...which covers a root.	MATURE EMBRYO Embryo elongating Camera moves around to tip to show the root cap and then the root to the inside.	
41.Nutrients now begin to accumulate in the surrounding female tissue.	NUTRIENT CONTENT Accumulation of nutrients	
42. Water is removed and the seed enters a resting or dormancy stage.	WATER CONTENT Removal of water Female changes colour and texture Lid back on the integument	
43. During this time, the ovule jacket has changed into a tough, protective seed coat.	SEED COAT Integument changing into the seed coat, going brown. Ovuliferous scale with two seeds.	

44. The seed and surface tissue of the cone scale separate together, forming a winged seed. Cone opening and seed release usually take place in the autumn of the second year.	SEED RELEASE Dissolve of scale to show wings with attached seeds.	
44a	INSERT REAL CONE OPENI.NG???	
SUMMARY • Each fertilised egg forms four embryos that are pushed out of the egg case.	FOUR NUCLEI STAGE	
• Only one embryo survives to form a miniature plant.	YOUNG EMBRYO AXIS showing cotyledons, etc	
• The female tissue accumulates nutrients and dries out.	FOOD PARTICLES GOING INTO OVULE AND WATER GOING OUT	
• The seed consists of an embryo, surrounded by female tissue, inside a protective seed coat.	CUT AWAY AFTER WATER HAS LEFT AND TOP PUT ON.	

	Seed Germination	
VOICE	IMAGES	REEL
45. When a seed is released from the cone and absorbs water, it is ready to germinate.	SEED: DARK DARK:Please lighten. a seed located on moist soil. Lid removed to see water particles going inside to the female tissue	
46. Nutrients stored within the female tissue are now consumed by the growing embryo.	NUTRIENTS: DARK DARK mobilisation of female gametophyte reserves Particles leaving female and going into cotyledons.	
47. The root, protected by the cap, grows into the soil to provide water and support for the stem.	ROOT: Root entering the soil.	
48. The stem now begins to grow and lift the seed out of the soil.	HYPOCOTYLE: Lid of seed coat removed. Stem and cotyledons begining to elongate	

49. When the seed coat is shed, the seed leaves expand and become green and photosynthetic.	EMERGENCE: showing the hypocotyl appearing above the soil and cotyledons greening Seed coat coming off. Cotyledons bending upward and greening. Cotyledons expending outward.	
50. The stem tip soon begins to form leaves and the seedling then proceeds to develop into another cone-bearing tree.	SEEDLING: Stem above cotyledons growing upwards.	
51.	SEEDLING: continued upward growth	
52.	LIVE FOOTAGE: Young pine tree Close, then pull back to tree in grassy area.	
SUMMARY. • The female tissue nourishes the growing embryo. .	DARK DARK : NUTRIENTS GOING FROM FEMALE TO COTYLEDONS	
• The embryo root grows out of the seed to anchor it and absorb water.	DARK DARK: ROOT COMING OUT	
• The embryo stem elongates, carrying the seed out of the soil	SEED BEING LIFTED OUT OF SOIL	
• The seed leaves expand and become photosynthetic.	COTYLEDONS EXPANDING, GREENING.	
FINALE With over 550 species, cone bearing seed plants have successfully adapted to many different habitats around the world.. The pollen grain has enabled these plants to evolve a form of internal fertilisation, breaking the dependence upon water to carry the sperm to the egg. The seed with its embryo and future source of nourishment, has replaced the spore as the unit of dispersal. . This combination of features has contributed to the success of these plants, which include the tallest, largest and longest-lived plants known.		